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The Canadian Entomologist

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The Canadian Entomologist

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The *phlogosaria* Complex of the Genus *Plagodis* (Lepidoptera : Geometridae)[1]

By E. G. Munroe
Insect Systematics and Biological Control Unit
Entomology Division, Ottawa

Rupert's excellent revision (1949) has greatly clarified the classification of the North American species of *Plagodis*. One of the most interesting features of Rupert's work was his demonstration by rearing that what had previously been considered a distinct species, *Plagodis keutzingaria* Packard, was in fact the spring generation of the aestival *P. phlogosaria* Guenée. By analogy it followed that *P. schuylkillensis* Grossbeck must be considered the summer generation of *P. purpuraria* Pearsall and *P. arrogaria* Hulst that of *P. fervidaria* Herrich-Schaeffer. Rupert was thus able to group in three species elements that had previously been distributed among six.

In this paper I restrict the "*phlogosaria* complex" to the forms listed by Rupert under the specific names *Plagodis phlogosaria* Guenée and *Plagodis purpuraria* Pearsall. Rupert considered *phlogosaria* a polytypic species, with three subspecies in eastern North America and one in the west; he considered *purpuraria* a distinct and monotypic species. Although the main outlines of this classification seem correct, study of a considerable series of specimens, many of which were not seen by Rupert, has suggested the revised arrangement set forth here.

The principal points of difference are as follows: I divide what Rupert considered as the single subspecies *approximaria* Dyar into two; I sink *intermediaria* Barnes and McDunnough to the subspecies *phlogosaria* Guenée but separate the population of part of the New England coast as a subspecies under the name *keutzingaria* Packard, which Rupert used for a seasonal form of *phlogosaria;* I divide what apparently corresponds to Rupert's concept of *purpuraria* into two subspecies and consider that two more may eventually prove separable. Finally, I believe that *phlogosaria* and *purpuraria* are in all probability conspecific. The last point deserves some amplification.

Rupert's concept of *purpuraria* included material from southeastern New York State, Maryland, eastern and western Pennsylvania, Ohio, and northern Illinois, but was based chiefly on an extensive series of specimens from western Pennsylvania. Rupert assigned populations from regions to the north of this range to the species *phlogosaria.* He described the differences between the two supposed species as follows: In the spring form, *purpuraria* has the purple terminal scaling extensive and smooth, not restricted and irregular as in *phlogosaria; purpuraria* has few or no striae on the under surface or on the median area above, and lacks a discal spot on the forewing, whereas in *phlogosaria* the striation is conspicuous and in the southern populations the discal spot is usually prominent. In the summer form, *purpuraria* has the postmedial line nearer the middle of the wing than in *phlogosaria* and has the entire forewing and the terminal area of the hind wing evenly dark-scaled; the tornal excavation is shallower in *purpuraria* than in *phlogosaria.* In the male genitalia no significant differences are apparent, but in the female genitalia – and these differences were regarded by Rupert as especially important – *purpuraria* has the ductus bursae proportionally narrower, the signum smaller and with fewer points, the sclerotized bar near the ostium

[1]Contribution No. 3901, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

broader and more strongly curved centrally, and the membrane behind this bar more conspicuous and more ragged than does *phlogosaria*.

The distinguishing feature of differences between sympatric species is not so much their size as their constancy, and particularly the constancy with which independently determined differences are associated with one another. There is no question that the differences between *purpuraria* and *phlogosaria* would be sufficient to establish these forms as species if these differences were constant and if they were firmly associated in their individual distribution.

This, however, does not seem to be the case. The differences listed are constant between *purpuraria* from western Pennsylvania and *phlogosaria* from, say, central New York; but over the total ranges of the two forms the differences are not by any means so striking or so stable. In eastern Pennsylvania, for instance, *purpuraria* is considerably more variable than in the western part of the state. The postmedial line is on the average closer to the outer margin than in the western Pennsylvania population; in the spring form the tornal patch is often reduced and usually vivid purple, rather than steely blue as is normal in western Pennsylvania specimens; most summer specimens from the east are smaller and much lighter in colour than those from the western part of the state. As we go north along the Atlantic coast, the average position of the postmedial line approaches the outer margin more closely. In the coastal regions of Massachusetts, New Hampshire, and southern Maine a different facies is found. Here the spring form has the striation of the wings considerably stronger and the antemedial band better developed. The following *purpuraria* characters are, however, retained: the discal spot is absent; the postmedial band rarely shows traces of sinuation, and is on the average rather far removed from the outer margin (as in all the subspecies, there is considerable individual variation in the position of the band); the tornal patch is usually large and always even and bright purple; and the antemedial band is considerably weaker on the average than in the spring form of *phlogosaria*. The facies of the summer form is closely similar to that of the summer form of *purpuraria* from coastal regions, but the average size is smaller, and a faint discal dot is present in a few specimens.

A somewhat similar form is found in the Chicago area. In the spring form this also has the tornal patch large, even, and bright purple to steely blue; the discal dot is lacking and the wings are at most weakly striated; the postmedial band is well removed from the outer margin. The antemedial band is, however, well developed, and the striation of the wings is on the average stronger than in *purpuraria*. The summer form has the ground colour pale, as in typical *phlogosaria*, but has the tornal patch and the discal dot weakly developed or absent, as in *purpuraria*.

The external appearance of the New England and Illinois populations seems to provide a definite connection between the extreme facies of *purpuraria* on the one hand and *phlogosaria* on the other. What, then, do the female genitalia show? I have examined 17 preparations of female genitalia, made from specimens of *purpuraria* facies, or from specimens of *phlogosaria* facies taken in localities close to the border-zone of *purpuraria* and *phlogosaria*. In this series I find that all the characters enumerated by Rupert assort with at least some degree of independence, instead of being rigidly associated, as one would expect if they were of specific importance. I can see no constant difference in the relative widths of the ductus bursarum in the preparations before me. The width varies widely from specimen to specimen, but without apparent correlation with external appearance or locality of capture. The width of the sclerotized bar near the ostium is perhaps greater on the average in the *purpuraria*-like forms, but in

certain otherwise normal specimens of *phlogosaria* from Scranton, Pa., and Montreal, Que., this bar is as wide and as strongly curved as in the most extreme specimens that I have seen from the Pittsburgh area. Likewise, the membrane behind the bar seems more ragged on the average in the western Pennsylvania population than in any other, but this condition is duplicated in individual specimens from other parts of the range. Perhaps the most nearly constant of the genitalic differences is in the size and spinulation of the signum. This structure is certainly on the average smaller and provided with fewer spines in the western Pennsylvania population than in any other. Again, however, even in the small series before me, there is the widest individual variation, and I do not think that any one of the subspecies of the complex could be recognized on the basis of this character alone.

Accordingly, there seems to be no warrant on purely morphological grounds for dividing the *phlogosaria* complex into two species. Any such division would have to rest on the demonstration of reproductively isolated populations coexisting in a single locality. Although I do not care on the present evidence to say that such a condition cannot exist, the strong indications of intergrading in morphology and maculation between the northern and southern forms seem to weigh against the possibility. There are, however, two bits of evidence that might be taken as support for the theory that *phlogosaria* and *purpuraria* are distinct, geographically overlapping species. One is the locality record for the type specimen of *purpuraria*: Scranton, Pa. Now, as several specimens before me show conclusively, almost typical *phlogosaria* (both spring and summer forms) occurs regularly at Scranton. If we could be sure that typical *purpuraria* also occurs normally at Scranton, there would be a good *prima facie* case for the specific distinctness of these two forms. I have, however, seen no other specimens of *purpuraria* from the Scranton region, except the type, which, moreover, is labelled as having been taken in *July*. If any form of *purpuraria* were to be taken at Scranton in July, it would almost certainly be the very different summer form, *schuylkillensis*. There is therefore intrinsic evidence that the label is false. The specimen is closely similar to several specimens from Philadelphia that I have seen, and I think it not improbable that Rothke (the supposed collector) obtained the specimen in or from the Philadelphia region in the spring, and that a mistake occurred in the labelling of the specimen. Alternatively, it can be supposed that Scranton is on or near the border-line of the ranges of the two subspecies, and that both occur in the vicinity of Scranton, perhaps at different elevations or in different habitats. The true situation can be ascertained only by critical collecting in the region.

The second piece of evidence is the fact (Rupert, in litt.) that there is an "apparent overlapping of geographical distribution, especially in western Pennsylvania". I have not myself seen specimens to support this statement. It should be remembered, however, that western Pennsylvania is a region of strong relief, with northeast-southwest trending mountain ranges alternating with river valleys. It would not be surprising, therefore, to find considerable interdigitation of the ranges of northern and southern forms, perhaps at different altitudes. A similar condition may prevail in the eastern part of the state, where *phlogosaria* extends well southward in the Scranton-Luzerne region.

Because of this evidence I do not absolutely rule out the possibility that *phlogosaria* and *purpuraria* may eventually be proved specifically distinct. In this paper, however, I follow what seems to me to be the most probable relationship, and consider all the forms as belonging to a single species.

On this basis, the populations can be divided according to maculation into three main groups. The first, typified by the subspecies *approximaria* Dyar, extends from Newfoundland and the coast of Maine westward to Vancouver Island and northern California. The second, comprising the single subspecies *phlogosaria*, extends in a narrow belt from western Maine and northern Pennsylvania to southern Manitoba. The third, typified by *purpuraria* Pearsall, ranges from southern Maine down the Atlantic coast at least to Philadelphia, and thence west to Iowa in a zone to the south of the range of typical *phlogosaria*.

The members of the first group are for the most part single-brooded, but at least a partial second brood occurs in western North America and in the southernmost parts of the range in the east. I recognize three subspecies in this group: *iris* Rupert, occurring in Maine and in Canada west at least to Hymers, Ont.; a new subspecies, described below, from Saskatchewan, Alberta, and the Northwest Territories; and *approximaria* Dyar, from British Columbia and adjacent regions. These subspecies agree in the large size, in the dull colouring, particularly of the tornal patch, in the absence of the discal spot, and in the shallow emargination of the external margin. On the average the antemedial and postmedial bands are more closely approximated and more sharply contrasting than in the second group. Although existing information leaves in the known range of the group a wide gap, from western Ontario to western Saskatchewan, it is not unlikely that further collecting will fill this.

I recognize only a single subspecies, *phlogosaria*, in the second group. The Ontario population, to the spring form of which the name *intermediaria* Barnes and McDunnough applies, and which Rupert listed as a valid subspecies, is in my opinion not separable with any degree of accuracy from *phlogosaria phlogosaria*.

The third group consists of at least three and possibly five subspecies. These are: *keutzingaria* Packard from Massachusetts and neighbouring regions of the Atlantic coast; *purpuraria*, ranging from Connecticut to Philadelphia and perhaps farther south, and in which I tentatively include the somewhat different population of western Pennsylvania; a new subspecies from the Chicago region; and what may be an additional subspecies from western Iowa. In the spring form these agree in having the striation of the wings reduced; the discal spot normally, and the antemedial band often, suppressed; and, except in the Iowa form, the tornal patch greatly expanded and the purplish tints in general emphasized. The summer forms are more varied and less sharply distinguished from the summer form of *phlogosaria*, but show a general tendency to dark suffusion and to suppression of the tornal patch and discal dot.

First Group of Subspecies

Plagodis phlogosaria approximaria Dyar

Figs. 1-6; 43

Plagodis approximaria Dyar, 1899: 266.
Plagodis phlogosaria race *approximaria*, Rupert, 1949: 32 (in part); Pl. II, Fig. 1; Pl. IV, Fig. 4; Pl. V, Figs. 10, 11.

Spring Form.—Forewing above luteous, with orange-brown or olive-brown suffusion, which tends to break up into striae, particularly on the disc; antemedial band diffuse, oblique, sometimes obsolescent, usually much less distinct than the postmedial, to which it tends to be closely approximated; discal dot absent; postmedial line distinct, incurved or, less commonly, straight or weakly bisinuate, varying from brown to dark fuscous bordered inwardly with brown; tornal patch of variable extent, blackish purple, scaled inwardly with light blue-gray; tornal

excavation shallow. Hind wing above pale luteous, faintly irrorated with brown, and sometimes extensively suffused with pink; postmedial line distinct and blackish at anal margin, becoming indistinct after a short distance and usually fading out well before the anterior margin; tornal patch of variable extent, shading from blackish to pinkish and heavily irrorated with light blue-gray scales, the pinkish shading often occupying the whole postmedial area and sometimes extending over the whole hind wing. Under side: fore and hind wings luteous with markings of upper surface repeated in pink or pinkish brown, the hind wing heavily striated or suffused with the same colour, especially on the distal half.

Summer Form.—Differing from the spring form in the smaller size, in the darker ground colour with duller brown suffusion and striation, in the much narrower and rather ill-defined antemedial lines, and in the reduction of the tornal patch of the forewings. The summer generation is evidently partial, as specimens are rare in collections. I have examined the genitalia of two males of this form: in one the furca is symmetrical, as described and illustrated by Rupert; in the other the right arm is longer, as in the summer forms of the eastern subspecies.

In addition to the normal spring and summer forms, a third form is represented by material reared under laboratory conditions by the Forest Insect Survey, Division of Forest Biology, Science Service. These specimens agree with those of the spring form in pattern, but are of a much darker colour than either the spring or summer form, the forewings being heavily suffused and striated with olivaceous and the hind wings with purplish.

Only material from the coastal zone of the British Columbia mainland and the northwestern United States is strictly typical of this subspecies. Specimens from Vancouver Island are on the average darker and more richly coloured and have the tornal patches more extensive than is normal in material from the mainland. Specimens from central and eastern British Columbia, from the Rocky Mountain region of Alberta, and from adjacent parts of the United States show varying degrees of transition to the following subspecies.

Specimens from the Forest Insect Survey are labelled as having been reared from *Betula*, from *Salix*, and from *Alnus*. A single specimen is labelled as having been reared from "cedar". This record should perhaps be considered doubtful.

Material Examined

Spring Form.—42 specimens, from the following localities: CALIFORNIA: Orlcany. OREGON: So. Fork Umpqua R., 14 mi. north of Tiller, Douglas Co.; Woodburn; Corvallis; Reed; Portland (paratype). WASHINGTON: Verlot, Snohomish Co. BRITISH COLUMBIA: Duncan, Wellington; Shawnigan District; Seton Lake, Lillooet; Salmon Arm; Kaslo; Fraser Mills; Rossland. IDAHO: Wallace. ALBERTA: Waterton Lakes.

Summer Form.—Seven specimens, from the following localities: OREGON: Gresham; McMinnville; Warrendale, Multinoma Co. WASHINGTON: Toutle, Cowlitz Co. BRITISH COLUMBIA: Agassiz.

Laboratory-reared Form.—21 specimens, from the following localities: BRITISH COLUMBIA: Port Renfrew Road; Shawnigan Lake; Seymour Creek; Capilano; Forest Grove; Eholt; La Kelse Lake; Sage Creek; Heffley Creek; Birch Island; Lumby; Paxton Valley; Creighton Valley; Mile 20, Alaska Highway. ALBERTA: South Gate, Waterton Lakes National Park; Lyns Creek, Crowsnest Forest District; Pyramid Lake, Jasper National Park.

***Plagodis phlogosaria bowmanaria*, new subspecies**

Figs. 7-12

Plagodis phlogosaria race *approximaria*, Rupert, 1949: 32 (in part).

In general appearance this subspecies closely resembles *approximaria* Dyar and *iris* Rupert. From both of these subspecies it differs in the larger average size, and in the strong and uniform suffusion or striation of the forewing. This suffusion or striation varies in colour from light orange-brown to rather dark olive brown, but is always so dense and extensive as to cover most of the wing, not becoming markedly paler in the medial and costal area as is usual in the other two subspecies. The tornal patches are on the average much less extensive than in *approximaria* and somewhat less so than in *iris*. The antemedial line is usually distinctly bisinuate.

As in the preceding subspecies, specimens reared under laboratory conditions are darker and more heavily suffused. Because of the dark facies of the majority of wild specimens, the difference is less noticeable than in *approximaria*.

There appears to be only one generation, of vernal type, flying in May and early June. Specimens have been reared in the Forest Insect Survey from *Salix* and *Alnus*.

Holotype, male, Edmonton, Alta., May 4, 1941 (Bowman), in the Canadian National Collection. Allotype, female, Edmonton, Alta., May 17, 1941, in the collection of Mr. K. Bowman, Edmonton, now at the University of Alberta.

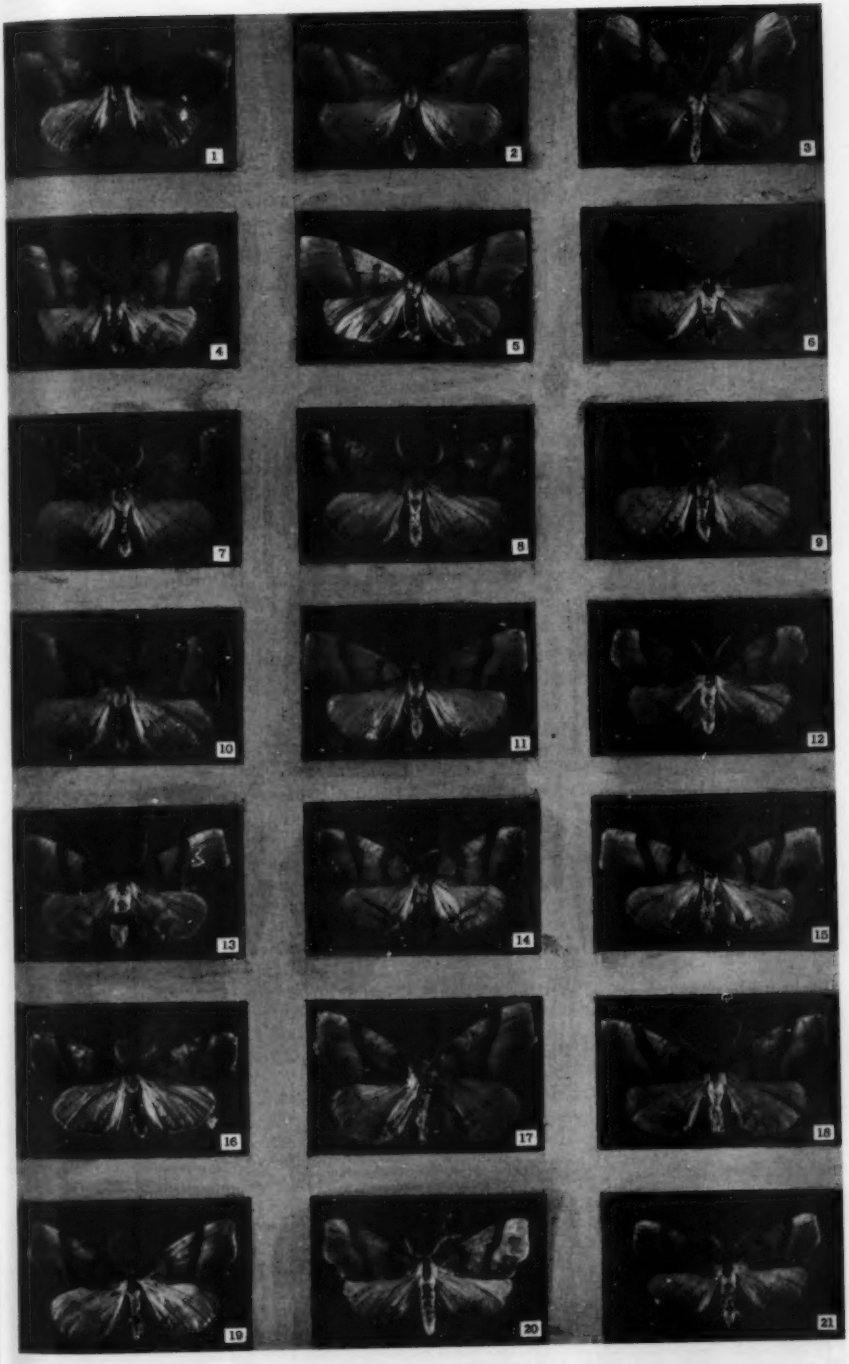
Paratypes are distributed as follows:

In the Canadian National Collection: one male, Sunnydale, Lloydminster, Alta., May 15, 1949 (Bruggemann); one male, Saskatoon, Sask., May 15, 1926 (King); one male, Harlan, Sask., June 5, 1941 (Bruggemann); one male, Yellowknife, N.W.T., May 17, 1948 (Cashman). Type No. 6003, C.N.C.

In the Bowman collection, now in the University of Alberta, Edmonton: six males, Edmonton, Alta., various dates in May.

In the United States National Museum: one male, Sunnydale, Lloydminster, Alta.; May 15, 1949 (Bruggemann).

Figs. 1-21, *Plagodis phlogosaria* subspp. 1, *P. p. approximaria*, spring form, ♂, Duncan, Vancouver Island, B.C., May 25, 1921, C.N.C.; 2, *P. p. approximaria*, spring form, ♂, Corvallis, Oreg., June 1-7, 1926 (Thompson), Coll. W. Bauer; 3, *P. p. approximaria*, spring form, ♂, 14 mi. N. of Tiller, Douglas Co., Oreg., June 1-5, 1948 (Frechin), A.M.N.H.; 4, *P. p. approximaria*, spring form, ♂, Salmon Arm, B.C., May 17, 1937 (Leech), C.N.C.; 5, *P. p. approximaria*, spring facies, ♀, Waterton Lakes, Alta., June 28, 1929 (Pepper), C.N.C.; 6, *P. p. ?approximaria*, ♀, Pyramid Lake, Jasper Nat. Park, Alta., reared from alder, emerged Jan. 13, 1950, Forest Insect Survey, Calgary, Alberta, (typical of dark specimens of western subspecies reared in Forest Insect Survey); 7, *P. p. bowmanaria*, holotype, ♂, Sunnydale, Lloydminster, Alta., May 15, 1949 (Bruggemann), C.N.C.; 8, *P. p. bowmanaria*, paratype, ♂, Saskatoon, Sask., May 15, 1926 (King), C.N.C.; 9, *P. p. bowmanaria*, paratype, ♂, Edmonton, Alta., May 22, 1929 (Bowman), ex Coll. K. A. Bowman, U. of Alberta; 10, *P. p. bowmanaria*, paratype, ♂, Edmonton, Alta., May 22, 1929 (Bowman), ex Coll. K. A. Bowman, U. of Alberta; 11, *P. p. bowmanaria*, paratype, ♂, Edmonton, Alta., June 4, 1942 (Bowman), ex Coll. K. A. Bowman, U. of Alberta; 12, *P. p. bowmanaria*, paratype, ♂, Yellowknife, N.W.T., June 17, 1949 (Cashman), C.N.C.; 13, *P. p. iris*, spring facies, ♀, Biscotasing, Ont., June 11, 1931 (Schedl), C.N.C.; 14, *P. p. iris*, spring facies, ♂, Biscotasing, Ont., June 10, 1931 (Schedl), C.N.C.; 15, *p. iris*, spring facies, ♀, Biscotasing, Ont., June 11, 1931 (Schedl), C.N.C.; 16, *P. p. iris*, spring facies, ♂, Mackinaw City, Emmet Co., Mich., June 21, 1947 (Voss), Coll. J. O. Voss; 17, *P. p. iris*, spring facies, ♀, Deer Lake, Nfld., June 13, 1903, A.M.N.H.; 18, *P. p. iris*, spring facies, ♀, Cascapedia R., P.Q., July 1, 1934 (Smith), C.N.C.; 19, *P. p. iris*, spring facies, ♀, MacNab's Island, N.S., July 29, 1907 (Bush-Wilson), C.N.C.; 20, *P. p. iris*, spring facies, ♂, Annapolis, N.S., June 29, 1946 (McDunnough and Ferguson), C.N.C.; 21, *P. p. iris*, spring facies, ♂, Annapolis, N.S., June 25, 1946 (McDunnough and Ferguson), C.N.C.



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Not included in the type series are two reared specimens from Kinuso, Alta., and Suadre, Alta.

Plagodis phlogosaria iris Rupert

Figs. 13-21; 44-45

Plagodis approximaria, Barnes and McDunnough, 1917: 248 (in part); Pl. XXII, Fig. 1.
Plagodis phlogosaria race *iris* Rupert, 1949: 31; Pl. V, Fig. 9.

This subspecies, described from Nova Scotia, proves to have a wide range, with little local variation, from Newfoundland and Maine to western Ontario. In most places it is single-brooded, but in Maine and some parts of Quebec there appears to be a partial second brood.

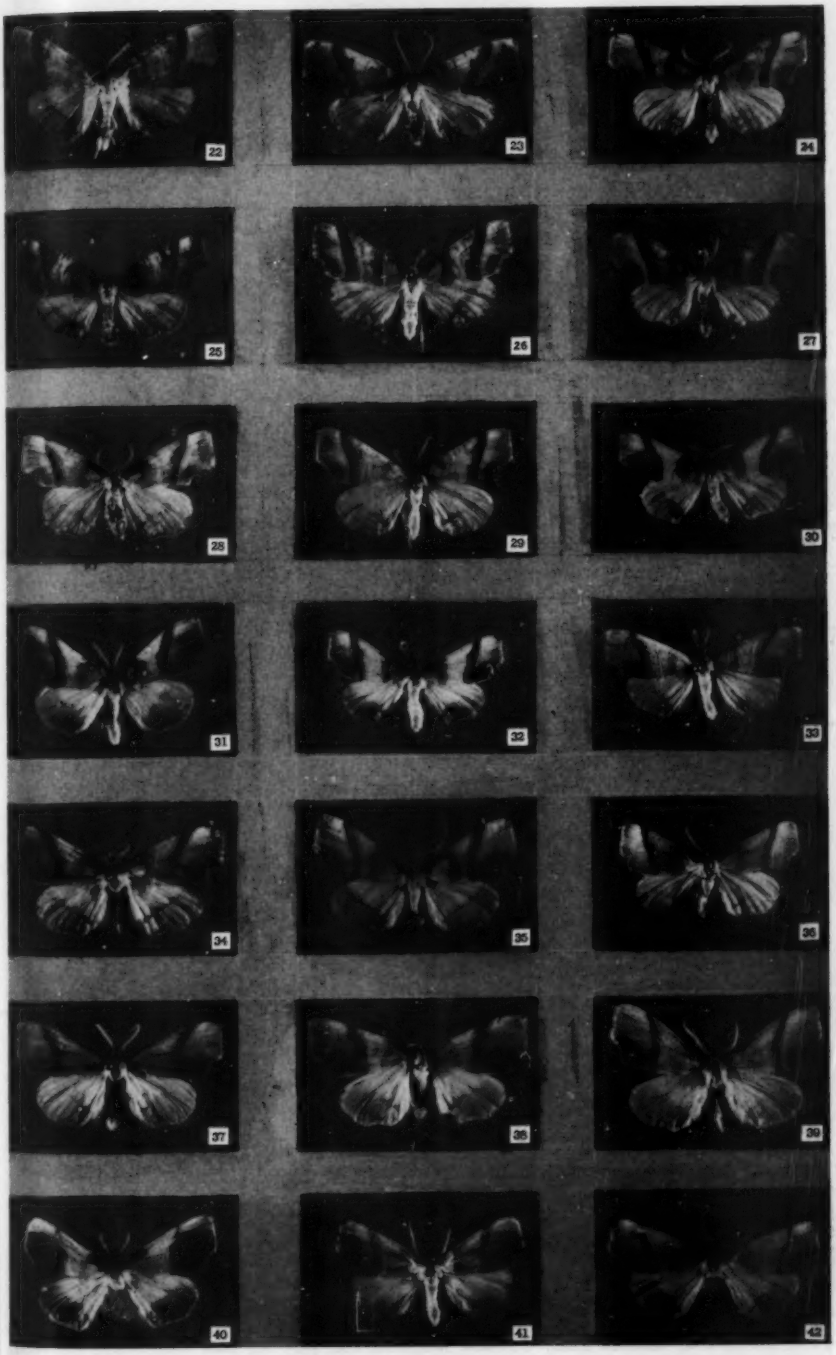
Spring Form.—Closely similar to *bowmanaria*, but differing in the smaller size, in the less dense striation, in the paler ground colour, in the broader and more contrasting transverse bands of the forewing, and in having the antemedial band about as well developed as the postmedial. There is some minor geographical variation, specimens from western Quebec and eastern Ontario being paler than those from more easterly localities.

Summer Form.—Closely similar to the corresponding form of *phlogosaria phlogosaria* and probably not constantly distinguishable. The few specimens examined are somewhat paler than is the rule in *phlogosaria phlogosaria* and lack the discal dot.

The subspecies evidently intergrades over rather a narrow zone with typical *phlogosaria*. At Ottawa, among a population of fairly typical *phlogosaria*, occasional *iris*-like specimens are found in the spring generation. Conversely, Rupert notes that in Nova Scotia specimens resembling the spring form of *phlogosaria* sometimes occur; there is in the Canadian National Collection a similar specimen from Biscotasing, Ont., where *iris* in nearly typical form is the normal representative of the species.

Specimens of *iris* have been reared in the Forest Insect Survey from *Betula* and *Alnus*. Another specimen, from Newfoundland, is labelled as having been reared from "fir"; this host record requires confirmation.

Figs. 22-42, *Plagodis phlogosaria* subspp. 22, *P. p. ?phlogosaria*, spring facies, ♂, Indian Head, Sask., June 6, 1936 (Stewart), Forest Insect Survey, Indian Head, Sask.; 23, *P. p. phlogosaria*, spring form, ♂, Aweme, Man., May 24, 1925 (Bird), C.N.C.; 24, *P. p. phlogosaria*, spring form, ♂, Macomb Co., Mich., Apr. 30, 1941 (Newman), Coll. J. H. Newman; 25, *P. p. phlogosaria*, spring form, ♂, Orillia, Ont., reared from basswood, emerged Jan. 1, 1945, Forest Insect Survey, Ottawa, Ont.; 26, *P. p. phlogosaria*, spring form, atypical ♂, Kirk's Ferry, P.Q., May 18, 1950 (Beirne), C.N.C.; 27, *P. p. phlogosaria*, spring form, ♂, Montreal, P.Q., May 10, 1903 (Lyman), Redpath Mus., McGill Univ.; 28, *P. p. phlogosaria*, spring form, ♂, Fourth Lake, Fulton Chain, N.Y., June 12 (Grossbeck), A.M.N.H.; 29, *P. p. phlogosaria*, spring form, ♂, Scranton, Pa., May 8, 1917 (Rothke), A.M.N.H.; 30, *P. p. ?illinoiaria*, spring form, ♂, Sioux City, Ia., May 20, 1916, U.S.N.M.; 31, *P. p. illinoiaria*, spring form, holotype, ♂, Edgebrook, Ill., May 16, 1917 (Kwiat), U.S.N.M.; 32, *P. p. illinoiaria*, spring form, paratype, ♂, Forest Park, Ill., May 7, 1939, Chic. Nat. Hist. Mus.; 33, *P. p. illinoiaria*, spring form, paratype, ♂, Evanston, Ill., May 14, 1896 (Snyder), Chic. Nat. Hist. Mus.; 34, *P. p. keutzingaria*, spring form, ♂, Hampton, N.H., May 25, 1917 (Shaw), Coll. A. E. Brower; 35, *P. p. keutzingaria*, spring form, ♂, Weston, Mass., May 7, 1923 (Paine), Coll. A. E. Brower; 36, *P. p. keutzingaria*, spring form, ♂, Weston, Mass., May 21, 1925 (Paine), Coll. A. E. Brower; 37, *P. p. purpuraria*, spring form, ♂, New Haven, Conn., May 11, 1883 (Foote), A.M.N.H.; 38, *P. p. purpuraria*, spring form, ♀, May 27, ex Strecker Coll., Chic. Nat. Hist. Mus.; 39, *P. p. purpuraria*, spring form, ♂, Garrett Rock, N.J., May 3, 1908 (Grossbeck), A.M.N.H.; 40, *P. p. purpuraria*, spring form, ♂, Oak Sta., Alleg. Co., Pa., May 9, 1913 (Marloff), Redpath, Mus., McGill Univ.; 41, *P. p. purpuraria*, spring form, ♂, New Brighton, Pa., Apr. 30, 1903 (Merrick), U.S.N.M.; 42, *P. p. purpuraria*, spring form, ♀, New Brighton, Pa., May 15, 1908 (Merrick), U.S.N.M.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Material Examined

Spring Form.—43 specimens, from the following localities: MICHIGAN: Mackinaw City, Emmet Co. *Ontario*: Biscotasing, Sudbury Co.; Bourkes, Timiskaming Co.; Hymers, Thunder Bay Co. QUEBEC: Laniel, Timiskaming Co.; Ste. Flore, St. Maurice Co.; Cascapedia R. Bonaventure Co.?. NEW BRUNSWICK: St. John. MAINE: Augusta; Springfield; Ashland; Bar Harbor. NOVA SCOTIA: Halifax; Annapolis; MacNab's Island; South Milford; Smith's Cove. NEWFOUNDLAND: Deer Lake; Baie Verte, White Bay.

Second Group of Subspecies

***Plagodis phlogosaria phlogosaria* (Guenée)**

Figs. 22-29; 46-51

Eurymene phlogosaria Guenée, 1857: 146.
Plagodis phlogosaria, Packard, 1876: 466.
Plagodis altruaria Pearsall, 1907: 206.
Plagodis intermediaria Barnes and McDunnough, 1917: 248; Pl. XXII, Fig. 2.
Plagodis phlogosaria, Rupert, 1949: 28 (in part); Pl. I, Fig. 5; Pl. IV, Fig. 1; Pl. V, Fig. 6.
Plagodis phlogosaria spring form *keutzingaria*, Rupert, 1949: 30 (in part); Pl. I, Fig. 6; Pl. IV, Fig. 2; Pl. V, Fig. 7.
Plagodis phlogosaria race *intermediaria*, Rupert, 1949: 31.

Spring Form.—Smaller than *iris*, with the tornal emargination deeper and the wings on the average somewhat narrower. Colour similar to that of *iris*, but with the red suffusion on the hind wings and on the under side less extensive, and with the brown suffusion and striations of the forewing above often paler and tinted with orange rather than olivaceous. Antemedial line usually somewhat less conspicuous than the postmedial; both lines, but especially the antemedial, with the black element tending to disappear, but with the brown medial border always well marked. Discal dot of forewing usually conspicuously present; striations tending to be fewer and coarser than in *iris*. Tornal patches about as in *iris*.

Summer Form.—Smaller than the spring form, with the wings relatively broader and the tornal emargination shallower. Ground colour luteous to dull brown, tinted with olivaceous, and finely and sparsely striated with dark brown; the hind wing paler and more olivaceous than the forewing. Transverse lines narrow, dark fuscous; discal spot black, punctiform; tornal patch blackish, more

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Figs. 43-63, *Plagodis phlogosaria* subspp., 43, *P. p. approximaria*, summer form, ♂, Agassiz, B.C., July 22, 1923 (Anderson), C.N.C.; 44, *P. p. iris*, summer form, ♂, Augusta, Me., July 11, 1944 (Brower), Coll. A. E. Brower; 45, *P. p. iris*, summer form, ♂, Augusta Me., Aug. 15, 1948 (Brower), Coll. A. E. Brower; 46, *P. p. phlogosaria*, summer form, ♂, Meach Lake, P.Q., June 28, 1941 (Hobbs), C.N.C.; 47, *P. p. phlogosaria*, summer form, ♂, Norway Bay, P.Q., July 10, 1937 (Urquhart), C.N.C.; 48, *P. p. phlogosaria*, summer form, ♂, Ottawa, Ont., July 20, 1905 (Gibson), C.N.C.; 49, *P. p. phlogosaria*, summer form, ♀, Big Indian Valley, Catskill Mts., N.Y., July 19, 1906 (Pearsall), A.M.N.H.; 50, *P. p. phlogosaria*, summer form, ♀, Big Indian Valley, Catskill Mts., June 17, 1906 (Pearsall), A.M.N.H.; 51, *P. p. phlogosaria*, summer form, ♂, Richmond Gulf, Sardinia, N.Y., July 18, 1939 (Rupert), Redpath Mus. McGill Univ.; 52, *P. p. illinoiaria*, summer form, ♀, Ill[inois], ex Strecker Coll., Chic. Nat. Hist. Mus.; 53, *P. p. illinoiaria*, summer form, ♂, [Illinois], ex Strecker Coll., Chic. Nat. Hist. Mus.; 54, *P. p. illinoiaria*, summer form, ♂, [Illinois], ex Strecker Coll., Chic. Nat. Hist. Mus.; 55, *P. p. ?illinoiaria*, summer form, ♂, Sioux City, Ia., Aug. 9, 1917 (Lindsay), U.S.N.M.; 56, *P. p. keutzingaria*, summer form, ♂, Weston, Mass., July 16, 1925 (Paine), Coll. A. E. Brower; 57, *P. p. keutzingaria*, summer form, ♂, Weston, Mass., July 10, 1925 (Paine), Coll. A. E. Brower; 58, *P. p. keutzingaria*, summer form, ♀, Newton Highlands, Mass., (Grossbeck), A.M.N.H.; 59, *P. p. purpuraria*, summer form, ♀, Norwich, Conn. (Pearson), Chic. Nat. Hist. Mus.; 60, *P. p. purpuraria*, summer form, ♂, Bear Mtn., N.Y., C.N.C.; 61, *P. p. purpuraria*, summer form, ♀, New Brighton, Pa., July 20, 1902 (Merrick), U.S.N.M.; 62, *P. p. purpuraria*, summer form, ♂, New Brighton, Pa., July 30, 1903 (Merrick), U.S.N.M.; 63, *P. p. purpuraria*, summer form, ♂, New Brighton, Pa., Aug. 7, 1903 (Merrick), U.S.N.M.

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definite and restricted than in the spring form, and with at most a very slight purplish tint.

This subspecies ranges with much individual but little geographical variation from New England to southeastern Saskatchewan, in a zone to the south of that occupied by *iris*. Vernal specimens from the region from Ottawa southward to Lake Ontario are on the average paler, with more strongly contrasting transverse lines and with sparser and coarser striations; it is doubtful, however, that individual specimens can be distinguished with any high degree of accuracy from specimens of the spring form of typical *phlogosaria*. The corresponding summer form is in my opinion indistinguishable from the summer form of *phlogosaria phlogosaria*. Accordingly, although the name *intermediaria* Barnes and McDunnough is available, I do not think that its use in a subspecific sense for this population is warranted. Rupert's assumption, based on McDunnough's (1933: 124) laboratory rearing experience, that *intermediaria* is single-brooded appears erroneous. As Barnes and McDunnough (1917) noted, there is an abundant emergence of the presumptive summer form in the Ottawa district, the type locality of *intermediaria*.

Specimens from southern Saskatchewan are somewhat larger and more suffused than those from the east, and can perhaps be considered transitional to *bowmanaria*.

I have seen specimens reared from the following host plants: *Betula lutea* Michx. f., *B. papyrifera* Marsh., *Carya* sp., *Quercus borealis* Michx. f., *Prunus pensylvanica* L., *Tilia americana* L.

Material Examined

Spring Form.—153 specimens, from the following localities: PENNSYLVANIA: Scranton; Luzerne Co. NEW YORK: Big Indian Valley, Catskill Mts.; Ilion; Horseheads; Fourth Lake, Fulton Chain; Sardinia; Ithaca. VERMONT: Clarendon. NEW HAMPSHIRE: Franconia. MAINE: Waterville. QUEBEC: St. Hilaire; Montreal; Brownsburg; Meach Lake; Kirk's Ferry; Fairy Lake. ONTARIO: Ottawa; Bell's Corners; Bobcaygeon; Constance Bay; Strathroy; Watson's Corner; South March; Orillia; Port Hope. MICHIGAN: Macomb Co. MANITOBA: Aweme; Miniota. SASKATCHEWAN: Indian Head; Katepwa Lake.

Summer Form.—165 specimens from the following localities: PENNSYLVANIA: Scranton; Luzerne Co. NEW YORK: Big Indian Valley, Catskill Mts.; Paul Smith's; Sardinia; Ithaca; McLean Bogs Reserve; E. Greenspan, Alegany. MASSACHUSETTS: Lenox. MAINE: Franklin Co.; Poland. "Canada" (paratypes of *phlogosaria* Gn.) QUEBEC: Bondville; Knowlton; Montreal; Brownsburg; St. Sauveur; Gracefield; Meach Lake; Norway Bay. ONTARIO: Ottawa; Merivale; Greely; Fennell; Uxbridge; Strathroy; Simcoe; London. MICHIGAN: Macomb Co.

An additional specimen of the summer form is labelled "Tex.", doubtless in error.

Third Group of Subspecies

***Plagodis phlogosaria keutzingaria* Packard, new status**

Figs. 34-36; 56-58

Plagodis keutzingaria Packard, 1876; 468 (in part).
Plagodis kuetzingaria [sic], Barnes and McDunnough, 1917: 249; 1917a: 155 (in part).
Plagodis phlogosaria, Rupert, 1949: 29 (in part).
Plagodis phlogosaria spring form *keutzingaria*, Rupert, 1949: 30 (in part).

Spring Form.—Intermediate in characters between the corresponding forms of the subspecies *phlogosaria* and *purpuraria*. Size and wing shape about the same as in *phlogosaria;* orange-brown striation much less extensive on the average; antemedial band diffuse and much weaker than the postmedial, which is usually

rather evenly incurved; bands on the average more closely approximated than in *phlogosaria,* less so than in *purpuraria;* discal spot absent or very weakly indicated; tornal patch variable in extent, on the average much more extensive and more purplish than in *phlogosaria* and always so in specimens as heavily striated as *phlogosaria.* From *purpuraria, keutzingaria* differs in the somewhat broader wings, in the more distinct antemedial band, and, in dark specimens, in the perceptible striation of the forewing. The postmedial band is better defined and on the average closer to the outer margin than in *purpuraria;* it is never erect and straight as in some specimens of *purpuraria.*

Summer Form.—Intermediate between the corresponding forms of *phlogosaria* and *purpuraria,* rather closely similar to many coastal specimens of the latter. Forewing darker than that of *phlogosaria,* with little or no striation and with the discal dot absent or hardly indicated and the tornal patch obsolescent; hind wing not or hardly striated, with the postmedial area contrastingly dark.

Because of its individual variability, this subspecies has given rise to some confusion in the literature and in manuscript determinations. Pale specimens of the spring form have usually been grouped with the spring form of *phlogosaria,* while darker specimens have often been determined as *purpuraria.* The summer form has usually passed as *purpuraria,* f. *schuylkillensis.* Even the rather short series at my disposal shows clearly that the light and dark forms belong to a single variable population; Packard's figure of *keutzingaria,* which according to Barnes and McDunnough agrees closely with the lectotype, and the figure given by Barnes and McDunnough after examination of the lectotype both fall within the normal range of variation of the subspecies, although the latter represents a rather pale specimen. It will be noted that in this paper the name *keutzingaria* is used to designate both spring and summer forms of a geographical subspecies, whereas Rupert used it to denote a seasonal form of the populations he included in *phlogosaria phlogosaria.*

Material Examined

Spring Form.—16 specimens, from the following localities: MAINE: Kittery Pt. NEW HAMPSHIRE: Hampton. MASSACHUSETTS: Weston; Cambridge; Newton.

Summer Form.—Five specimens, from the following localities: MASSACHUSETTS: Weston; Newton Highland; Cohasset.

***Plagodis phlogosaria purpuraria* Pearsall, new status**

Figs. 37-42; 59-63

Plagodis keutzingaria Packard, 1876: 468 (in part).
Plagodis purpuraria Pearsall, 1907: 207.
Plagodis schuylkillensis Grossbeck, 1908: 315.
Plagodis purpuraria, Rupert, 1949: 26 (in part); Pl. I, Fig. 4; Pl. III, Fig. 6; Pl. V, Fig. 4.

Spring Form.—Forewing pale, suffused or very weakly striated with orange of a varying degree of brightness; antemedial line obsolete or obsolescent; discal spot absent; postmedial line on the average, but not invariably, far removed from the outer margin, most often incurved, but sometimes straight and almost erect; tornal patch strongly developed, varying from rich purple to steely blue. Hind wing pale luteous to yellow, with the postmedial area usually heavily suffused with purplish or bluish.

Summer Form.—Rather similar to the corresponding form of *phlogosaria phlogosaria,* but with the forewing and the postmedial area of the hind wing much darker, the antemedial line often weak, the discal dot absent or faintly indicated, and the tornal patches greatly reduced. Distinguishable from the corresponding form of *keutzingaria* by the larger average size and the darker average colour.

In the spring form the typical population from the Atlantic coastal area appears to differ from that of western Pennsylvania in average characteristics. In the coastal population the size is larger, the forewing narrower, the postmedial band nearer the margin and more strongly curved, the orange suffusion brighter, and the tornal patch is usually bright purple, not steely blue as it most often is in specimens from western Pennsylvania. In individual specimens, however, there is much overlapping of these characters; in the summer form there are perhaps no tangible differences.

I have seen the types of *purpuraria* and *schuylkillensis*, and also the two specimens from the Strecker collection mentioned by Pearsall in the original description of *purpuraria*. As noted above, the locality and date records associated with the type of *purpuraria* are questionable.

Material Examined

Spring Form.—45 specimens, from the following localities: CONNECTICUT: Hartford; New Haven. NEW YORK: Bear Mtn.; Maspeth, L.I. NEW JERSEY: Paterson; Garrett Rock.; "L. Mx."; Browns Mills. PENNSYLVANIA: Philadelphia region; Homebrook; "Scranton" (type of *purpuraria*); Oak Station, Allegheny Co.; New Brighton; Finleyville; Sharksburg. VIRGINIA: Montgomery Co.

Summer Form.—51 specimens, from the following localities: CONNECTICUT: Norwich. NEW YORK: Bear Mtn.; Poughkeepsie. PENNSYLVANIA: Falls of Schuylkill; Roxborough; New Brighton; All[eghen]y; Beaver Co.; Finleyville. VIRGINIA: Hot Springs; Arlington. NORTH CAROLINA: Pineola. SOUTH CAROLINA: Greenville.

***Plagodis phlogosaria illinoiaria*, new subspecies**

Figs. 30-33; 52-55

Spring Form.—Size small. Forewing rather broad; ground colour pallid, with some orange suffusion and usually with very sparse striations, the medial area normally almost unmarked; antemedial band reddish-brown, diffuse, normally much more distinct than in *purpuraria*, rarely obsolescent; discal spot absent or very faintly indicated; postmedial band distinct, blackish at least posteriorly, brown inwardly and toward the costa, normally incurved, on the average considerably more remote from the outer margin than in *phlogosaria phlogosaria*, spring form, but somewhat less so than in the spring form of *purpuraria;* tornal patch much more extensive than in the spring form of *phlogosaria phlogosaria*, usually purplish, rarely with a steely blue tint. Hind wing as in *purpuraria*, spring form, but with the postmedial suffusion on the average more purplish.

Summer Form.—Similar in size and colour to the summer form of *phlogosaria phlogosaria*, but on the average with the antemedial line more oblique, the postmedial line more regular and farther from the outer margin; discal dot usually absent, sometimes weakly present. Tornal patches of both fore and hind wings much less definite than in *phlogosaria phlogosaria*.

This rather well-defined subspecies is represented in the material before me, as detailed below, by a series from the region of Chicago, Ill. A spring specimen from Toledo, Ohio, perhaps belongs here, but might almost equally well be referred to *purpuraria*, as the antemedial band is indistinct and the tornal patch has a steely blue cast. Four spring specimens and two summer specimens from Sioux City, Iowa, agree in markings with *illinoiaria*, but are much more pallid, having lost in the spring form most of the reddish and orange tints, and in the summer form most of the yellow. One of the spring specimens is more heavily striated than the rest, and is transitional to the spring form of typical *phlogosaria*.

The spring form shows an obvious relationship to *purpuraria*, from the western Pennsylvania population of which occasional specimens can probably not

be separated. The summer form, on the other hand, is closer in general appearance to that of *phlogosaria phlogosaria*, although such characters as the suppression of the discal dot and tornal patch link it with the summer form of *purpuraria*.

Holotype, male, Edgebrook, Ill., May 6, 1916, A. Kwiat, in the United States National Museum. Allotype, female, Evanston, Ill., 5.4.96, A. J. Snyder, in the Chicago Natural History Museum.

Paratypes are distributed as follows:

In the Canadian National Collection: one male, Edgebrook, Ill. Type No. 6004.

In the United States National Museum: three males, Edgebrook, Ill.

In the Chicago Natural History Museum: two males, Forest Park, Ill.; one male, Evanston, Ill.

In the collection of Mr. A. K. Wyatt, Chicago, Ill.: four males, two females, Edgebrook, Ill.

In the collection of Mr. J. G. Franclemont, Ithaca, N.Y.: one male, Edgebrook, Ill.

In the collection of Mr. M. O. Glenn, Henry, Ill.; one male, Putnam Co., Ill.

In the collection of Mr. Leslie Banks, Chicago, Ill.: one male, Edgebrook, Ill.; one male, Morton Grove, Ill.

In the collection of Dr. A. E. Brower, Augusta, Me.: one male, Chicago, Ill.

The type material is all of the spring form. I have examined 20 specimens of the summer form, from the following localities: Ill[inois]; Edgebrook, Ill.; River Grove, Cook Co., Ill.; Chicago, Ill.

Summary

The subspecies previously ascribed to *Plagodis phlogosaria* (Guenée) and *P. purpuraria* Pearsall are revised. These two taxa are considered conspecific. The subspecies are placed in three groups, a northern one with three subspecies, a central one with a single subspecies, and a southern one with three subspecies. The subspecies *keutzingaria* Packard is separated from the subspecies *phlogosaria*, and two new subspecies are described: *bowmanaria*, type locality Edmonton, Alta., and *illinoiaria*, type locality Edgebrook, Ill.

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Observations on the Life-Cycle of the Balsam Woolly Aphid, *Adelges piceae* (Ratz.), in the Willamette Valley of Oregon[1]

By A. Tunnock and J. A. Rudinsky
Oregon State College, Corvallis

The balsam woolly aphid, *Adelges piceae* (Ratz.) (Adelgidae, Homoptera), originally introduced from Europe, was reported on grand fir, *Abies grandis* (Doug.) Lindl., in the Willamette Valley by Keen (5) around 1930. Serious outbreaks of this insect were first recorded on subalpine fir, *A. lasiocarpa* (Hook.) Nutt., in Oregon and Pacific silver fir, *A. amabilis* (Dougl.) Forb., in Washington in 1954 (3). At present about 600,000 acres of subalpine and Pacific silver firs are heavily infested in the Pacific Northwest.

Since this insect represents a serious threat to the true-fir forests of the Northwest, the biology of the aphid and its effect on hosts are being studied intensively. Investigations on the life-cycle of *A. piceae* in the Willamette Valley of Oregon were conducted during 1957, and the results are presented herein.

To summarize, the climatic and ecological conditions of the Willamette Valley proved to be very favorable for the development of *A. piceae* during 1957. By October, four generations of *A. piceae* had been completed. It should be pointed out that the climate of the Willamette Valley has been classified as a marine west coast type, but it differs from the typical marine west coast climate in normally having hot, dry summers.

Life-Cycle in Other Regions and Countries

The life-cycle of the balsam woolly aphid, as of all Adelginae, is complex. The insect generally overwinters in the first instar (neosistens) of the hiemosistens generation. Each sistens generation has three nymphal instars and parthenogenetic females.

In the spring a second type of progeny, called progrediens, may appear on the same tree. Some of the progrediens can develop wings and fly to nearby firs. Progrediens differs from the sistens, in that it will feed on the needles while the sistens does not, and there are four nymphal instars per generation. Progrediens occurs only occasionally in Eastern Canada (1) and is more common in Europe (8), (7). The progrediens has not yet been observed in the Northwest.

[1]Technical Paper No. 1158, Oregon Agricultural Experiment Station.

Fig. 1. Plots, 3" x 3", on a pole-sized grand fir for studying the subsequent generations of *Adelges piceae* (Ratz.).

Eggs laid by adult progrediens and hiemosistens develop into one or more summer generations termed aestivosistens. The number of generations per year varies and seems to depend on host species, climate, altitude, and even the form of *A. piceae* (2). Balch (1) reports that only two generations can complete development in the Maritime Provinces of Canada, where the summers are short and cool and the winters are severe (temperatures often drop to −30°F). Two generations have also been recorded for the Mount St. Helens area of Washington (3). In Europe the life-cycle differs slightly in regions of milder climate. These regions usually have mild, wet winters with occasional freezing periods, and the summers are warm and moist. In Germany the insect has been found overwintering also in the second and third instars (7), and a small third generation has been known to occur in France (6), Aberdeen, Scotland (8), and Germany (4).

Methods of Investigation

Observations of the development of *A. piceae* were made on a large grand fir (*Abies grandis*) on the campus of Oregon State College, elevation 230 feet.

Fig. 2. A swivel type microscope used in studying the development of *Adelges piceae* (Ratz.).

The tree had a d.b.h. of 23 inches and was about 85 feet tall. A heavy population of *A. piceae* inhabited the bark of the trunk and larger branches. "Gouting" or swelling of the terminal buds was noticeable.

Through the winter and spring months, the method of observing the development of *A. piceae* consisted simply of collecting samples of infested parts at weekly intervals. The samples were carefully examined under a dissecting microscope, and all stages of development were recorded.

By June it became difficult to distinguish stages of the second generation from the third generation on the large grand fir. To avoid confusing the generations, a new method of observation was adopted. On June 21, three three-by-three-inch plots (Fig. 1) were established on the bark of a pole-sized grand fir about 20 feet from the first, large grand fir. The plots were divided into half-inch squares by red marks made on the bark with a wax pencil. The new tree had a very light infestation of *A. piceae* on its trunk. All the aphids found within the plots were removed. To keep first-instar larvae from crawling into the plots, cotton strips were secured around the margins of the plots with pieces of three-quarter-inch rope nailed on over the strips. Pieces of bark with the eggs of the second generation were cut from the large grand fir and pinned on the plots so as to cover the plotted area. The bark was placed with the infested side against the bark of the new host. As the eggs hatched the young larvae crawled over to the fresh bark within the plots.

Insect pins were used to mark the location of each established aphid. The development of each individual was recorded from week to week by marking

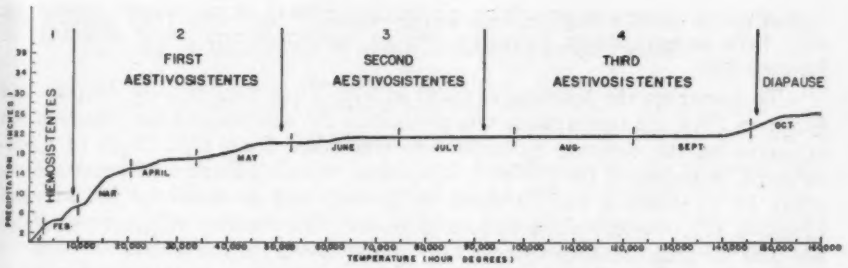

Fig. 3. The development of the balsam woolly aphid, *Adelges piceae* (Ratz.), in the Willamette Valley, Oregon in 1957 as correlated with temperature (sum of hour-degrees) and precipitation.

the pins with a red wax pencil. To mark the successive stages, the following marks were used:

Plain pin	First instar
One red mark . . .	Second instar
Two red marks . .	Third instar
Three red marks . .	Adults (with or without eggs)
Red mark on head . .	Sistens of the next (fourth) generation

Observations were made by focussing a swivel type microscope (Fig. 2) on the top left hand corner of a plot. Specimens in each half-inch square sub-plot were then examined as the microscope was swung to the right. When the right-hand margin of the plot was reached, the microscope was then lowered to the next line of sub-plots and swung back to the left. This scanning procedure was continued until the bottom of the plot was reached. The sub-plots helped to orient the microscope on the plot.

The daily temperatures were recorded by a hygrothermograph near the grand firs.

Results

The results from the weekly observations of the development of *A. piceae* on grand fir are summarized in Table I and in Fig. 3. The dates in Table I indicate the first time that particular stages of development were observed within each generation.

TABLE I

Occurrence of the Stages of the Sistentes within each Generation on *Abies grandis* for 1957 at Corvallis, Oregon

Stages	Generations			
	I	II	III	IV
1	2–14–57*	3–30–57	6–4–57	8–8–57
2	2–14–57	5–16–57	7–5–57	?
3	2–28–57	5–16–57	7–16–57	8–30–57
Adults	2–28–57	5–28–57	7–24–57	10–9–57

*Overwintering neosistens.

Initial development (moulting of the first instar) of the winter generation may have begun before February 14; no second instars were detected on January 29.

To construct the bioclimatic curve in Fig. 3 (as used also by Merker and Eichhorn (7)), the temperature was plotted on the abscissa and the precipitation in inches on the ordinate (precipitation was taken from U.S. Dept. of Commerce, Climatological Data, Vol. LXIII, Nos. 1-12). The sum of temperatures above 32°F, which is the threshold of development as stated by Merker and Eichhorn (7), was expressed in hour-degrees. The number of generations and the time of their development (Table I) are shown on the curve.

There were four generations of *A. piceae* in 1957. The fourth generation finished development about October 9, or after 147,000 Fahrenheit hour-degrees (Fig. 3).

The study showed that the number of eggs laid by a single female varied a great deal. The hiemosistentes were the most productive, and one female laid over 110 eggs by April 16.

Development seemed most rapid during July and August. For instance, a second instar on August 8 had developed into an egg-laying adult by August 14.

Summary

Since 1954, *Adelges piceae* (Ratz.) has become a serious threat to the true fir forests of Oregon and Washington. A study of the life-cycle of *A. piceae* in the Willamette Valley was conducted at Corvallis, Oregon, during 1957.

The method of following the successive generations is described. *A. piceae* overwintered as a first instar or neosistens, and development started early in February. By October the aphid had gone through four generations. The insects' development was correlated with temperature and precipitation.

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The Effect of Light and Temperature on the Behaviour of Adults of the White Pine Weevil, *Pissodes strobi* Peck.[1]

By C. R. SULLIVAN
Forest Insect Laboratory, Sault Ste. Marie, Ontario

INTRODUCTION

This study was undertaken as part of an investigation of the physical and biological requirements of the white pine weevil, *Pissodes strobi* Peck. The broad aspects of the main problem will be given in a later paper and it need only be mentioned here that the immediate objective was to define the requirements of the weevil in terms of measurable factors of the environment. During the field studies, observed variations in behaviour between individual weevils within the limits of a single habitat indicated the need for additional studies that would permit analysis of behaviour in relation to previous conditioning. The responses of the adult weevils to diffuse and discrete light sources, and the effect of temperature on these responses, were investigated in conjunction with field studies of behavioural changes during relatively stable and variable weather conditions, in an attempt to explain observed weevil movements.

The weevil overwinters in the adult stage. Emerging from infested leaders of white pine during late summer, the adults pass through an active period of about two months before they enter hibernation at the onset of unfavourable autumn weather. Upon resumption of activity the following spring, they pass through a second active period of about two months or less, during which time the eggs of the succeeding generation are deposited in the leaders of the host tree. These periods of activity are characterized by marked differences both in the general climate and in weevil behaviour and activity. At this point it should be emphasized that any differences in behaviour observed between active weevils in autumn and spring occur within the same generation, but at different periods in its life. Consequently, in this paper adults will be referred to as the autumn and spring populations to simplify reference to age groups.

LABORATORY INVESTIGATIONS

Experimental Material

Adults of the spring population were collected in the field and kept under insectary conditions in six-cm. rearing jars until required for experiments. Sections of freshly cut white pine leaders were provided as food. Adults of the autumn population were obtained in infested leaders collected in the field during late July and placed in emergence tubes in the insectary. In the tubes, the adults moved towards the light into cellophane bags placed over the open end of the tubes. From here they were collected and transferred to the rearing jars. Food was renewed every five days.

Methods

The responses of adult weevils to point sources of light were observed on a light board originally designed by A. W. Ghent (unpublished data). This apparatus differed from other types in that the insect platform was constructed from "plexiglass' which was marked off by radiating lines extending at 30° angles from the light source and intersecting arcs of concentric circles spaced at equal intervals from the lamp. This grid was viewed from beneath by means of a mirror, the surface of which was covered by a sheet of clear "cellophane". The movements of an adult placed on the platform could be observed, and easily traced on the "cellophane" with a wax pencil. The light source consisted of a 2.4

[1]Contribution No. 521, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada; based on part of a thesis submitted as partial fulfilment for the degree of Doctor of Philosophy at Macdonald College, McGill University, 1957.

volt flashlight lamp. The insects were placed on the platform approximately one foot from this source.

With the light board, observations were made on the responses of fed and starved individuals of the autumn and spring populations and on the effect of light conditioning on these reactions. The starvation period varied from 24 to as long as 140 hours, which was only a few hours before death. Three types of light conditioning were used. Insects were held for 24 hours under constant light, constant darkness, or under normal daily light rhythms, at approximately 20°C and 60% R.H.

A dark-light alternative chamber described by Wellington (8) was used during the initial observations of the responses of adult weevils to diffuse light. In these experiments the insects were sensitive to a slight shadow pattern formed along the dark-light boundary, so that there was some difficulty in distinguishing between photopositive and photonegative responses. This difficulty was overcome in subsequent tests with a modified type of chamber described by Green (3) for testing the effect of temperature on the light reactions of sawfly larvae and later used by Wellington *et al.* (10), with slight modifications, during studies with the spotless fall webworm. When a rising temperature was desired, a single 200-watt bulb served as the heating unit and the light source. The heat from the bulb served to warm a water supply below the reaction platform, the rate of temperature increase being regulated by the amount of water used. Heating the water raised the chamber temperature and kept the enclosed air saturated, thus eliminating any possible effects of increased evaporation rate with increasing temperature on the reaction of the insects. When testing the reactions of adult weevils at moderate temperatures, it was necessary to use an overhead lamp.

Chamber temperatures were measured with a thermocouple junction placed in contact with the silk platform in a central position in the chamber. Each time an insect moved out of the lighted portion of the chamber the temperature was recorded. Preliminary tests showed that only small numbers of adults could be observed efficiently at any one time in the chamber. Large numbers lowered the accuracy of the observation because, on occasion, one or more insects that had moved across the boundary would return to the lighted portion. Therefore, ten insects were used in each test. Before testing, fed and starved adults of the autumn and spring populations were conditioned for a period of 12 hours to temperatures of 20 ± 2, 12 ± 2, and 0 ± 1°C.

The results were analysed to obtain the mean reversal temperature or the temperature at which the insects moved from the lighted to the dark portion of the chamber. Analysis of variance tests showed that there was no significant difference between the temperatures at which members of each replicate became photonegative. Consequently, the mean reversal temperature obtained by group analysis was accepted as the true mean and further analysis simply involved calculating its standard error.

Results

Reactions to a Point Source

During experiments on the light board it was found that light conditioning did not affect the response of fed adults or adults starved for 24 hours, of either the autumn or spring populations. All insects exhibited a photopositive response, and no difference in their rates of movement could be attributed to the type of previous light conditioning. Also, in consecutively run tests no appreciable

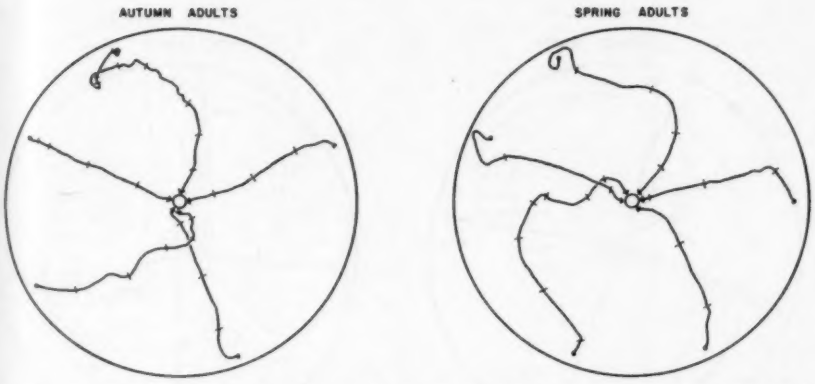

Fig. 1. Representative paths taken by *P. strobi* adults in response to a 2.4 volt flashlight lamp. Insects conditioned for 24 hours on food at room temperature. Time marks represent 10-second intervals.

difference could be detected in the time required to reach the light between groups conditioned in total darkness and the other groups. Thus, the possibility of light adaptation of weevil adults could be eliminated and additional rearings were carried out under normal daily light rhythms.

Examples of typical reactions of fed adults of the autumn and spring populations are shown in Fig. 1, which shows the position of the insects at 10-second intervals during the tests. Although light adaptation could be ruled out, differences were observed between members of a single group. The chief variation was in the time required by individuals of a group to complete the reaction and this appeared to be due to the extent to which the paths were convoluted. Raising the temperature of the light board resulted in an increase in the speed of movement, but the paths taken appeared to be equally irregular.

When the adults were starved for 24 hours and then placed on the light board, they showed a stronger photopositive response by exhibiting a tendency to more direct paths. Examples of typical paths of members of the two populations are shown in Figs. 2A and $2A_1$. Consecutive trials showed no consistent change in the type of response. Additional starvation to two days before death resulted in a slower rate of movement along somewhat more irregular paths (Figs. 2B and $2B_1$), but the reaction was still strongly photopositive.

Differences in the response of individual adults became apparent after starvation up to 24 hours before death, but no consistent single pattern of behaviour was demonstrated (Fig. 3). This was particularly true among members of the autumn population, which took at least four different paths. First, individuals which reacted strongly positively (e.g.,–tracks 2 and 3 of diagram A, Fig. 3) generally maintained these headings during subsequent trials. Secondly, during initial trials, some adults failed to reach the light (track 1, diagram A) during an observation period of ten minutes, but in their second trial moved almost directly to the light (track 1, diagram A_1), and in their third trial would revert to prolonged periods of indifference before moving to the light (track 1, diagram A_2). The third type of reaction is shown in track 6 of diagrams A, A_1, A_2. In these cases, the insects reacted photopositively during their initial trials, but paths taken to the light were quite indirect. During subsequent trials, however, they reacted

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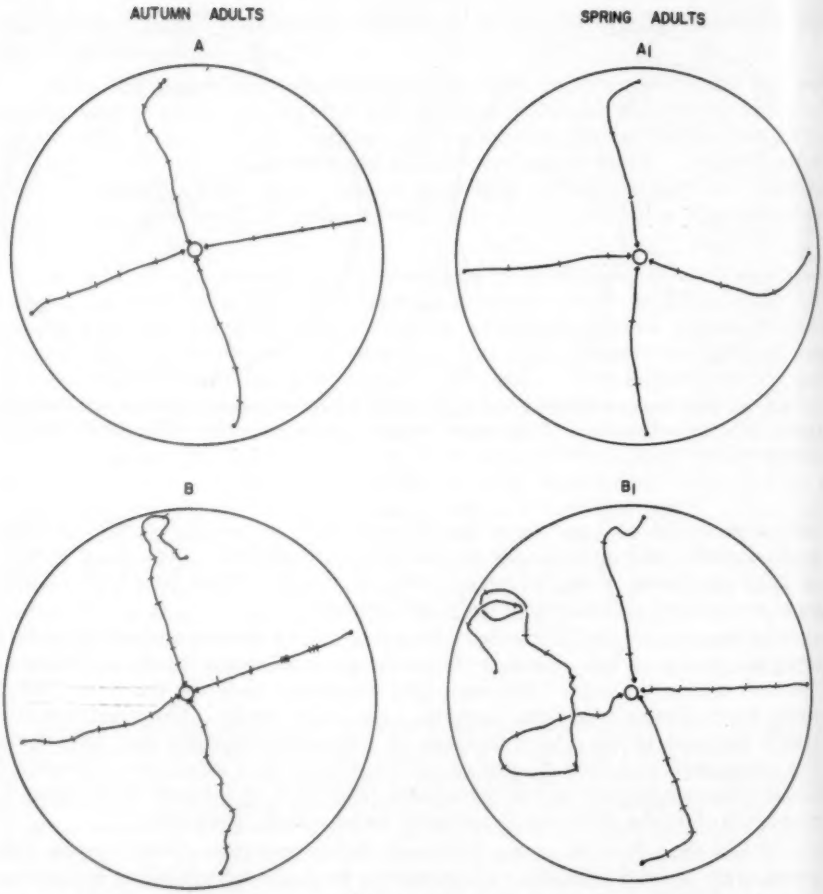

Fig. 2. Representative paths taken by adults of the autumn and spring populations of *P. strobi* in response to a 2.4 volt flashlight lamp. Tracks in A and A_1 made by adults starved for 24 hours. Tracks in B and B_1 made by adults starved up to 48 hours before death. Time marks represent 10-second intervals.

strongly photonegatively and maintained their heading during the period of observation. As indicated by the time marks shown in the diagrams, the insects were quiet throughout most of the observation period, and prodding with a brush failed to induce additional movement. The fourth and most commonly observed response took the form shown in tracks 4 and 5 of diagrams A, A_1, A_2. The insects exhibited a long period of indifference during their initial trial, but during subsequent trials this was progressively reduced until they moved almost directly to the light in the third trial.

After starvation until 24 hours before death, individuals of the spring population showed a much greater consistency in their response to the light source (Figs. 3B, B_1, B_2) than did the members of the autumn population. During initial trials (tracks 1, 2, and 3) the insects exhibited a more intensely positive

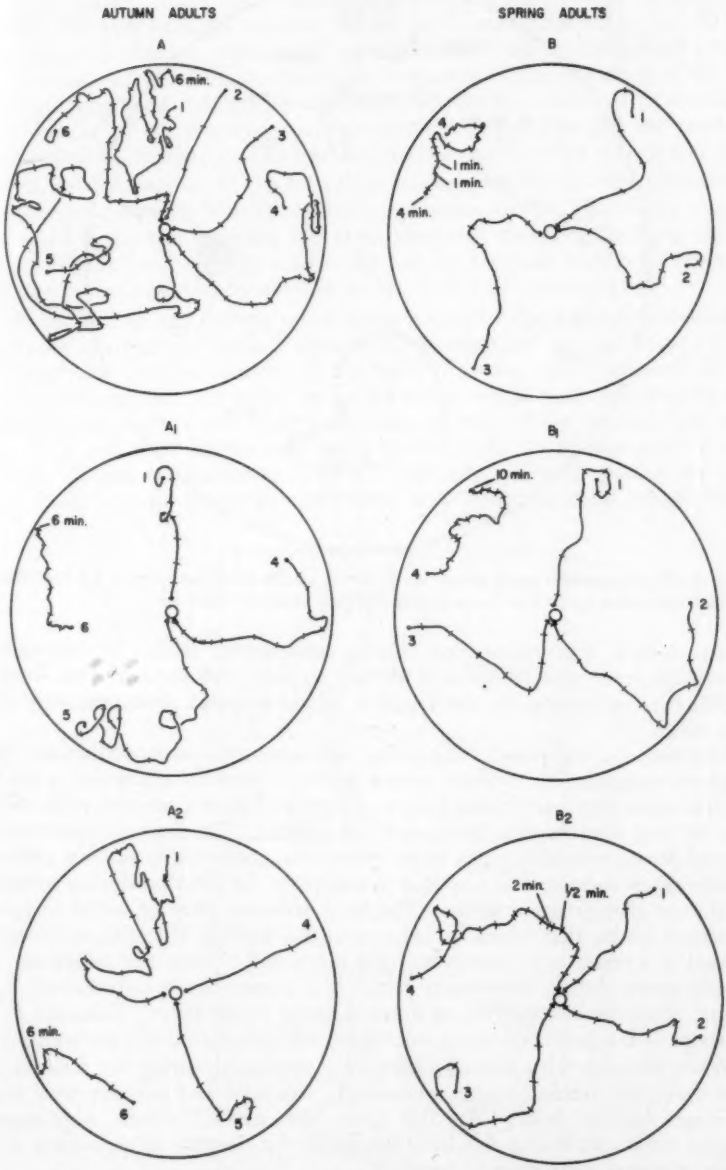

Fig. 3. Representative paths taken by adults of the autumn and spring populations of *P. strobi* in response to a 2.4 volt flashlight lamp. Insects starved up to 24 hours before death at room temperature. Tracks in A, A_1, A_2 and B, B_1, B_2 respectively, represent consecutive trials with brief time lags between each. Time marks represent 10-second intervals except where shown.

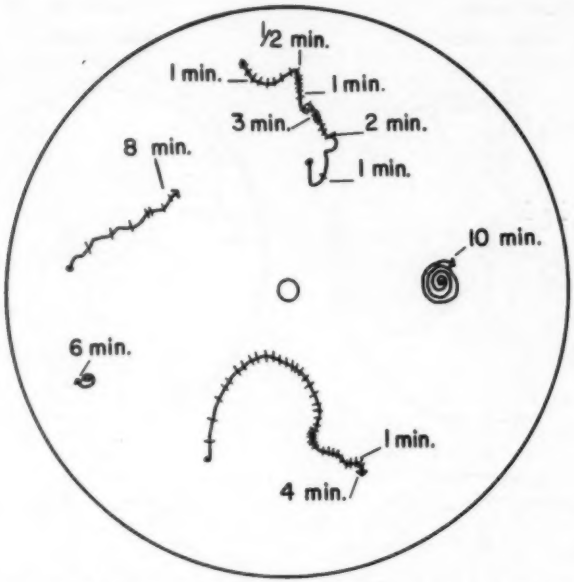

Fig. 4. Representative paths taken by *P. strobi* adults in response to a 2.4 volt flashlight lamp after starvation up to five hours before death at room temperature.

reaction, which was maintained during subsequent trials. Occasionally an adult would react photonegatively during its first and second trials (track 4, Figs. 3B, B_1) but during the third trial it would respond photopositively (track 4, Fig. $3B_2$).

As noted, the responses of the spring and autumn populations that are starved for periods extending to 24 hours before death function to take them to the light. The chief differences are in the length of time and the number of trials required before definite photopositive behaviour is expressed. The initial responses of the spring adults are normally much more direct than those of the autumn adults, and the paths taken and the time required to complete the reaction during subsequent trials do not change appreciably. The most common type of initial reaction of the autumn adults, that which includes extended periods of indifference, may be expressed as a reaction to particular light intensities. Since this behaviour tends to break down during subsequent trials, it is somewhat overshadowed by the stronger, more direct tendency to move directly to the light. Common to both age groups is the tendency of an occasional individual to react photonegatively.

When the tests with starved adults were continued during the final 24 hours before death, the tracks became increasingly irregular and indirect until four or five hours before death. At this time the adults became photonegative. Examples are shown in Fig. 4, which also show that the rate of movement and the amount of travel were sharply reduced.

Reactions to diffuse light

During the initial tests in the Wellington chamber, the chamber was divided so that one half was dark and the other half light. The light source was overhead. Adult weevils placed in the lighted half of the chamber remained quiet in this section until the chamber was heated. With an increase in temperature

the insects moved about the lighted portion, often taking up positions near the light-dark border where they remained through a wide range of rising temperature. At temperatures between 34 and 40°C, many moved to the dark and, by the time the chamber was heated to near 45°C, all adults had moved from the light to the dark half of the chamber. It is doubtful if the tendency of the adults to remain along the border of the dark-light boundary would have been observed in the absence of the secondary shadow pattern in the area and the results had to be verified by further tests in the modified Green chamber referred to earlier.

The chief difference in the behaviour of the adults in the two chambers was in the temperature at which they became photonegative. The range continued to be quite large, but with the increased sharpness between the light and dark sections, the insects failed to exhibit the border reaction mentioned above and consequently became clearly photonegative at lower temperatures.

Adults of both age groups, when given a choice between light and dark portions of an alternative chamber, after being conditioned at approximately 20°C and 60 per cent relative humidity for at least 12 hours, remained relatively quiet in the lighted section. On occasion, an individual would move temporarily across the border, but it was quite evident that the majority of the adults perceived the border line, and their movements were restricted to the lighted portion of the chamber. Adults acclimated to 12 or 0°C normally remained quiet in the lighted section until warmed to room conditions, at which time they reverted to the

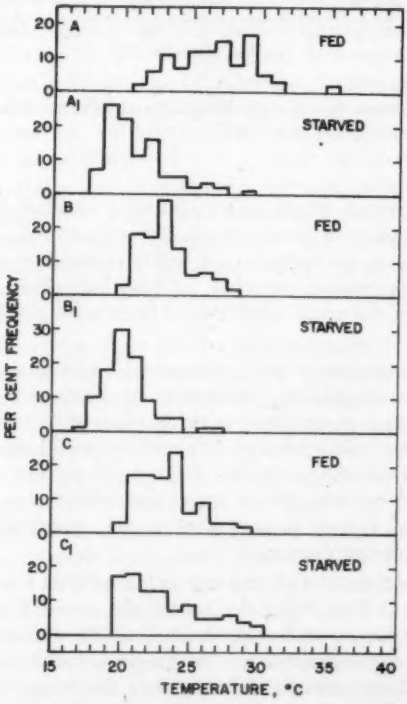

Fig. 5. Comparison of the ranges of temperature at which fed and starved adults of the autumn population of *P. strobi* became photonegative to diffuse light after acclimation to: A-A_1, 20 ± 2°; B-B_1, 12 ± 2°; C-C_1, 0 ± 1°C.

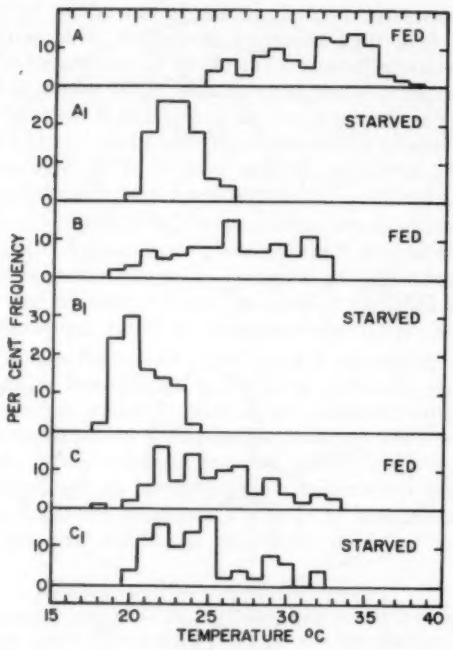

Fig. 6. Comparison of the ranges of temperature at which fed and starved adults of the spring population of *P. strobi* became photonegative to diffuse light after acclimation to: A-A_1, $20 \pm 2°$; B-B_1, $12 \pm 2°$; C-C_1, $0 \pm 1°C$.

typical behaviour described above. Occasionally, an adult that had moved into the darkened section failed to return to the lighted section. Adults starved during acclimation at the three temperature levels reacted in much the same way when placed in the alternative chamber. These behaviour patterns were more fully understood when the adult responses to light with rising temperatures were determined.

As the reversal temperature was approached, individuals of both age groups showed indications of impending movement by increased antennal movement, brushing of the head and mouthparts with the fore-legs, and short, jerky movements. This behaviour was generally followed by rapid movement to the dark. Occasionally an adult would return to the lighted section of the chamber but then it either reversed its direction of travel and returned to the dark or it continued rapidly in the original direction of travel, re-crossing the boundary at another point on its circumference.

Reversal temperatures of fed and starved adults of the autumn and spring populations are shown in Figs. 5 and 6, respectively, which illustrate the frequency distributions obtained when adults, acclimated to 20, 12, and 0°C for 12 hours, were tested in the alternative chamber. Although broad temperature ranges were obtained, the results show marked differences in the temperature levels at which starved and fed weevils acclimated to temperatures above 0°C became photonegative to diffuse light.

The mean reversal temperatures of fed and starved weevil adults collected

TABLE I

Comparison of the mean reversal temperatures at which fed and starved adults of the autumn and spring populations of *P. strobi* became photonegative in saturated air after acclimation to three temperature levels for 12 hours.

Accl. t. (°C)	Autumn Population			Spring Population		
	20	12	0	20	12	0
Fed adults						
n	100	100	100	100	100	100
$\bar{x}$ (°C)	26.4	23.2	23.4	31.4	26.3	25.4
$S_{\bar{x}}$	.281	.187	.205	.323	.355	.339
Starved adults						
n	100	100	100	50	50	50
$\bar{x}$ (°C)	20.9	20.4	23.4	22.7	20.6	24.6
$S_{\bar{x}}$	.227	.172	.290	.184	.206	.447

n, sample size; $\bar{x}$, mean reversal temp.; $S_{\bar{x}}$, standard error of mean.

during the *autumn* are included in Table I. Successive pairs of these means were subjected to t-tests. The results indicated that fed adults acclimated to 20°C became photonegative at a significantly *higher* temperature than adults acclimated to 12° and 0°C ($P<0.01$), but no significant difference was indicated between the means of the last two groups ($P>0.40$). Among starved adults, however, there was no significant difference between the reversal temperatures of those acclimated to 20° and 12° ($P>0.05$), but both groups became photonegative at significantly *lower* temperatures ($P<0.01$) than the adults acclimated to 0°C.

The mean reversal temperatures of the autumn adults also show the effect of starvation on the response. Fed adults acclimated to 20° and 12° became photonegative at significantly *higher* temperatures than starved weevils acclimated to similar temperatures ($P<0.01$). At 0°, however, the presence or absence of food during acclimation was not associated with corresponding changes in reversal temperatures.

Table I also shows the mean reversal temperatures of fed and starved weevils collected during the *spring* and tested in the alternative chamber. When successive pairs of these means were subjected to t-tests, the results indicated that fed adults acclimated to 20° became photonegative at a significantly *higher* temperature than fed adults acclimated to 12° or 0°C ($P<0.01$), but only borderline significance at the five per cent level was indicated between the mean reversal temperatures of insects acclimated to the last two levels.

The mean reversal temperature of *starved* spring adults, acclimated to the three temperatures, were all significantly different ($P<0.01$). Adults acclimated to 20° and 12°C reversed at lower temperatures than those acclimated to 0°C. Comparison of these means with those determined for fed weevils showed that fed adults acclimated to 20° and 12° became photonegative at significantly *higher* temperatures than starved adults acclimated to similar temperatures ($P<0.01$). These tests also indicated no significant difference between the reversal temperatures of fed and starved weevils acclimated to 0°C ($P>0.10$).

Although adults of both the autumn and spring populations react similarly to light when subjected to varying periods of starvation and to rising temperature,

there are some striking differences in the temperatures at which the responses occur, especially among the fed adults (Table I). The means obtained at each acclimation temperature were compared. These tests indicated that fed adults during the spring season became photonegative at significantly *higher* temperatures than fed adults during the autumn season ($P<0.01$). Similarly, at the 20° acclimation level, starved adults of the spring population became photonegative at a significantly *higher* temperature than starved adults tested during the autumn ($P<0.01$). The same relationship held between starved adults acclimated to 0° ($P<0.05$). The mean reversal temperatures obtained at the 12° acclimation level were, however, practically identical and no statistically significant difference was indicated ($P>0.40$).

FIELD INVESTIGATIONS

Materials and Methods

The field studies were carried out in an open-growing plantation of young white pine, *Pinus strobus* L., located at the Petawawa Forest Experiment Station, Chalk River, Ontario. The insects occurred abundantly in the stand so that adults could be observed by examination of naturally occurring groups on the trees with little or no interference by the observer. Occasionally, during the autumn, additional records were obtained by inspection of groups of adults on caged trees containing a known number of insects. When this was done, the insects were given at least a 24-hour establishment period before the observations were begun. Records on the behaviour of groups were augmented by critical examination of whole trees and continuous observation during specific periods when differences between the behaviour patterns of individuals confined to a single habitat became evident. Since the term habitat may be interpreted differently, it is here defined as the confines of a single white pine tree, about five feet in height, and the ground cover within a radius of two to three feet from its base.

In conjunction with the biological observations, measurements of temperature at particular points in the habitat pertinent to weevil behaviour were obtained with No. 24 copper-constantan thermocouples and a Rubicon portable potentiometer. During the initial studies, the measurements were made with a potentiometer that required a reference junction. The reference temperature was obtained by mounting a thermometer within the potentiometer housing. At each observation, the millivolt and thermometer readings were recorded consecutively. Actual temperatures of pertinent sites were obtained by means of an alignment chart. Throughout most of the studies, however, a potentiometer calibrated to read directly in degrees centigrade and containing a compensating reference junction was used for measuring the temperatures of the thermocouples. A ten-foot lead that could be readily connected to a series of thermocouples in turn was attached to this instrument. The technique of setting up the thermocouples and the accuracy of the records obtainable has been described in detail by Wellington (9). These data were supplemented by records from standard Stevenson screen equipment, an Eppley pyrheliometer, and hourly observations on cloud types and amounts, wind speed and direction, and types and duration of rainfall for the daily period 0800 to 2000 hrs., E.S.T.

Results

(a) *Spring population*

During the spring when the adults emerge from hibernation, they attempt to move up the trees in accordance with their photopositive reaction at low temperatures and their negatively geotactic reaction. However, time of emerg-

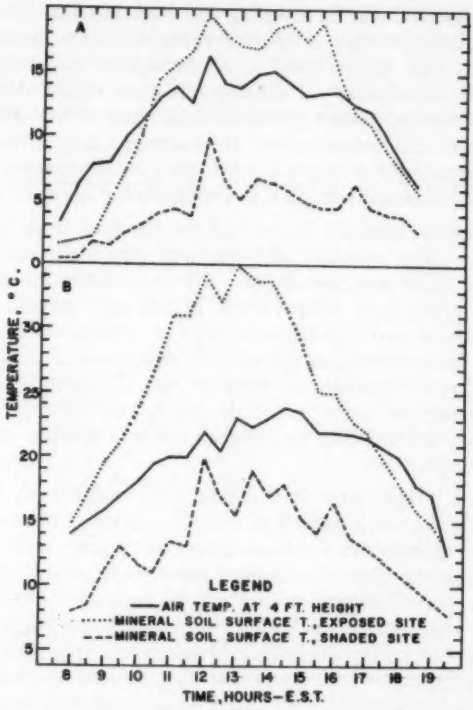

Fig. 7. Comparison of temperatures at hibernation sites of *P. strobi* adults and the air temperature on relatively clear days during the early portion (A) and latter portion (B) of the period of emergence.

ence varies in relation to the temperature and exposure of the hibernation site, so that adults in exposed areas are frequently activated well in advance of those that have overwintered in shaded sites nearer the base of the trees. Observations have shown that emergence occurs only when the hibernation sites have warmed to about 6°C or above and, as shown in Fig. 7, the effect of radiant heating on the temperature of the two sites is clearly defined. Adults in exposed areas, reacting as starved insects, frequently become overheated and respond photonegatively. This movement places them near the base of the trees and, when the temperature permits, they move directly up to the leader. This travel is often limited by low temperature during the early part of the season but, as the season progresses and the shaded sites become warmer, their movements are less restricted by temperature.

Weevil adults may travel through a wide range of temperature within the limits of a single habitat. The level and variation in the diurnal temperatures of the habitat and, consequently, the amount of weevil activity, depend on the time of day and season, and on exposure. The season is characterized by rising temperatures and dropping moisture so that during the early portion, relatively cool weather prevails, whereas the later part is relatively warm. These conditions are reflected in the temperatures of weevil habitats. Fig. 8 shows habitat temperatures pertinent to weevil behaviour on relatively clear days during the early and later portions of the period of activity of the spring adults. This figure

clearly shows the general rise in ambient and habitat temperatures as the season progresses. In addition, at exposed points of the habitat (e.g., the bark surface of an exposed leader) the temperature is maintained at a level higher than the temperature of the surrounding air throughout most of the daylight hours. On the other hand, at shaded points of the habitat, such as the bark and ground at the base of the trees, the temperatures are normally below the air temperature. Temperature differences of as much as 13°C may be experienced by adults travelling from the upper exposed sites to the lower shaded areas of the habitat.

The adults feed on both the leader and the terminal buds and oviposit in the bark of the leader. The intensity of these activities is directly dependent upon the temperature of these sites, particularly the bark of the leader. Consequently, during early spring, the daily temperatures permit only an abbreviated period of feeding and oviposition activity, which is kept at a relatively low level. Later in the season, higher temperatures at the activity sites result in a high level of weevil activity, which persists throughout most of the daylight hours. It should be mentioned that during the latter part of the spring the terminal buds have expanded into new shoots, so that they no longer enclose a pocket of air warmer than that of the surrounding air.

Terminal bark temperature is a product of ambient air temperatures and insolation. During the early period of weevil activity, ambient air temperatures are often below levels associated with activity, but leader bark temperatures during periods of maximum insolation (about solar noon at this time of year) may be raised to limits permitting a low amount of activity. However, later in the year, ambient air temperatures are more often within the range associated with a relatively high level of weevil activity. Moreover, at this time of the season the greater elevation of the sun from early morning to late afternoon provides more radiant energy and so maintains leader bark temperatures at levels associated with high weevil activity. Hence, as the season progresses, the daily period of high weevil activity is extended, starting earlier in the morning and ending later in the afternoon and evening.

Clouds produce a general drop in the range of temperature differences observed. Thin cirriform and broken cumulus clouds allow sufficient insolation to raise the bark temperature of an exposed white pine leader up to 5.5°C above air temperatures ranging between 15 and 28°C. This represents a reduction of only about 1-2°C from the range of temperature differences occurring on clear days. Under a heavy overcast of cumuliform or stratiform cloud, the bark temperature of a leader does not exceed the air temperature by more than 2.2°C. During rain, the bark temperature of a leader varies slightly above and below the air temperature, but the differences are negligible. In conjunction with any drop in the bark temperature of the leader, there is a general lowering of weevil activity.

When the bark temperature of the leader does not rise above 25°C the insects exhibit a more or less orderly trend of diurnal behaviour. During early morning, they rest at the base of the trees and among the terminal buds. As they are warmed and activated they move to the most exposed sector of the leader, which is on the east side early in the day. As the day progresses, they move around the leader, keeping within the more exposed sectors until late evening, when they take up positions in the west and north sectors. Bark temperatures in exposed sectors may range as high as 4°C above those of shaded sectors and the insects, by keeping to exposed positions, remain within temperature zones permitting greater activity.

During periods when the bark temperature ranges between 25 and 32°C, observations on groups of adults reveal random movements that can only be interpreted through a knowledge of their reactions to light and temperature. Thus, a single observation on a group of weevils on a leader may show insects feeding and ovipositing on exposed and shaded sectors, others moving up and

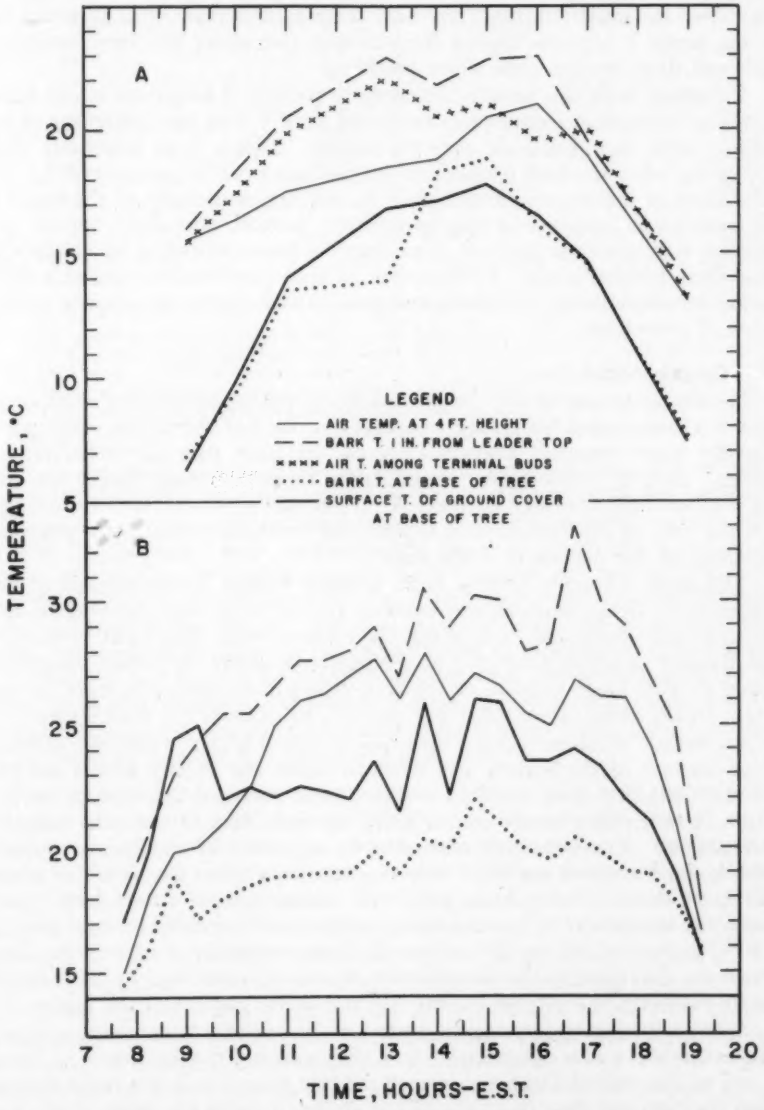

Fig. 8. Comparison of temperatures at various points within an exposed habitat of *P. strobi* adults and the air temperature on relatively clear days during (A) late April and (B) late May.

down these sectors, and still others moving out to the ends of needles in preparation for flight. This variation in behaviour is the result of the previous temperature conditioning of the insects. For example, some of them may be moving from shaded, cooler temperature zones and hence have not become overheated, whereas others that have been exposed and overheated are beginning to shift to shaded, cooler sectors of the habitat. At temperatures above about 32°C, those insects that have not left the leader begin congregating in the shaded sectors. Many leave the leader entirely. At bark temperatures near 38°C all adults have left the leader. At these higher temperatures the adults are very sensitive to touch and drop readily after slight prodding.

Variations from this more or less orderly pattern of behaviour occur following sudden changes in temperature associated usually with the movement of cool, modified polar continental air over the station. This is most noticeable during early spring when the bark temperature of the leader can drop to near 0°C. The adults move to the warmest sites within the habitat, at the base of the tree. No light reaction is involved in this movement. Instead, the adults appear to be following a temperature gradient, since they are photopositive at all temperatures below their reversal range. Continuance of cool conditions or unstable frontal weather accompanied by cloudiness and precipitation results in complete cessation of weevil movement.

(b) *Autumn population*

In contrast to that of the spring population, the season of activity of autumn adults is characterized by falling temperatures, so that during its early portion relatively warm weather prevails, whereas its later part has relatively cool weather. Habitat temperatures are similar to those occurring during the spring (Fig. 8), but their sequence is reversed. Thus, the season of activity, extending from the time of emergence until hibernation, is characterized by a progressive shortening of the periods of daily activity.

The adults normally emerge from infested leaders during periods of rising temperature. At air temperatures between 10 and 20°C, they move to the upper portion of the dead leader, but as this region is warmed they react in much the same manner as adults emerging at temperatures above 20°; they drop to the ground or to a lower portion of the tree, crawl down the main stem, or begin flight. In any event, their behaviour removes them from the dead leader.

Individuals observed moving up towards a dead leader commonly continued to the junction of the healthy and attacked wood but usually would not move over the boundary onto the dead wood. After repeated attempts to move on the dead portion they would return down the main stem or out onto one of the lateral shoots. This behaviour seemed to be regulated by the bark temperature of the leader because it occurred only on clear days when the bark was warmed to 27°C or above. On such days the bark temperature of a dead leader ranged from 2.5 to as much as 6.5° above the air temperature when this ranged from 15° to 30°C and from 0.5 to 3.5° above the bark temperature of a living leader. Hence, the difference in the temperatures of the dead and healthy bark was frequently sufficient to limit weevil travel to the living portion of the leaders.

As with the spring population, young adults of the autumn group are normally photopositive at temperatures below their reversal ranges shown in Table I, but one of the main differences between the two groups is in the temperatures at which they reverse their reaction. Thus, during autumn the adults show a preference for the most exposed parts of the habitat and when these sites are overheated they move to the shaded sites. When forced to move to the shaded

TABLE II

Comparison of temperatures pertinent to weevil activity at various points in a typical weevil habitat and the air temperature at four feet above ground level: October 10, 1952.

Time	1	2	3	4	5
0900	6.7	4.8	−3.8	−1.9	3.3
1000	7.9	3.0	−3.9	−0.7	6.0
1100	10.2	5.9	−3.8	−2.4	6.0
1200	10.5	2.7	−4.7	1.3	3.8
1300	11.1	3.8	0.2	0.2	9.0
1400	12.8	1.2	−2.1	−1.0	8.0
1500	11.8	6.2	4.7	3.0	6.9
1600	9.3	2.8	0.9	0.5	0.2
1730	−1.0	1.7	3.1	2.4	−0.6

Code: 1. Air temperature at four feet above ground level.
2. Bark temp. of white pine leader minus No. 1.
3. Bark temp. at base of tree minus No. 1.
4. Temp. of hibernation site at base of tree minus No. 1.
2. Temp. of exposed hibernation site minus No. 1.

sites, however, they may continue to feed. At bark temperatures exceeding about 27°C, the adults leave the exposed sites and move to the shaded sections of the leaders and laterals and continue feeding. At bark temperatures above about 31°C, they are seldom found on the leaders, but a search of the lower foliage reveals many feeding in shaded areas at bark temperatures below 27°C. The temperature differences between the exposed and shaded sites indicate the effect of solar radiation on the habitat. Once in the shaded sites, the autumn adults do not show as strong a tendency as the spring adults to move back to the exposed sites. Thus, as fed insects, they do not exhibit such strong photopositive responses. However, during late afternoon and evening, when the intensity of solar radiation has decreased and the shaded habitats have been cooled, the adults move back to the more exposed, but not overheated, sites.

Weevil adults are sensitive to temperature changes for a brief period before they enter hibernation. Although relatively low temperatures prevail at this time of the year, the adults may be warmed sufficiently to permit movement up the trees to the feeding sites where they remain for a few hours around mid-day and early afternoon. During the late afternoon, these sites undergo a sharp drop in temperature when insolation is reduced to near zero. Subsequent movement to the warmest sites removes the adults to the base of the trees (Table II). This movement corresponds with the travel of the older adults during periods of near-freezing temperatures in the spring. They are following a temperature gradient and are not influenced in any way by differences in light intensity. On subsequent days, if the mean air temperature remains below about 5°C, very little movement occurs and the adults begin hibernation. On the other hand, if subsequent days are warmer, the adults move back up the trees or out from their bases. Table II shows that steep vertical and horizontal temperature gradients occur from the shaded to the exposed sites on the trees and on the ground, and

TABLE III

Temperatures of *P. strobi* activity and hibernation sites on a relatively clear day approximately five days after the completion of hibernation: October 26, 1952.

Time	1	2	3	4
1000	4.9	−0.5	−3.4	−4.1
1100	7.5	−0.4	−4.9	−3.9
1300	9.5	1.0	−6.4	−6.4
1400	7.5	0.7	−1.2	−0.5
1500	7.8	0.5	−3.9	−2.4
1600	8.5	−0.1	−4.0	−3.4
1700	3.9	1.7	−1.0	−2.0

Code: 1. Air temperature at four feet above ground level.
2. Bark temp. of white pine leader minus No. 1.
3. Temp. of shaded hibernation site at base of tree minus No. 1.
4. Temp. of exposed hibernation site three feet from base of tree minus No. 1.

the direction of movement of the insects is dependent on the level of the temperature at the lower end of the ranges, particularly during the morning. Thus, they exhibit a strong photopositive reaction that often results in movement on a horizontal rather than a vertical plane. Consequently, the number of insects found in shaded and exposed hibernation sites is a joint function of their response to temperature as well as light.

After all the insects have entered hibernation, the temperatures of pertinent sites within the confines of a single habitat still vary in relation to the degree of exposure, but they are for the most part reduced to levels below that associated with weevil activity even on relatively clear days (Table III). This table shows that there is very little difference between the temperatures of the exposed and shaded hibernation sites. The exposed sites may vary as much as 1.5°C above the shaded sites during the hours of incident solar radiation, but during early morning and late afternoon they are cooler. At these times, back radiation from the exposed sites is stronger than in the shaded sites, so that they are cooled to lower levels.

DISCUSSION

There are several aspects of the reactions of weevil adults to discrete light that require some discussion. It should be mentioned first, however, that the variations among the responses of adults starved up to one or more days before death are not related to the actual number of days they have been starved but to the length of time before death. During the tests that required a conditioning period of starvation, it was observed that adults of the spring population could survive approximately one day longer than adults of the autumn population (roughly, death occurred on the sixth and fifth day, respectively). This difference in life-span, together with the normal variation about the mean death rate of starved weevils, tended to confuse the results until it was realized that an orderly set of responses occurred in relation to the length of time before death. It is a point worthy of consideration during investigations dealing with the behaviour of starved insects, particularly when conditioning includes prolonged periods of starvation.

One of the chief points to be noted is that adult weevils are basically photopositive to discrete light and this response is maintained to a greater or lesser degree until a few hours before death due to starvation. At this time they become strongly photonegative. Such changes in photic orientation are not uncommon and, in fact, may be much more striking among other insects. For example, Wellington (8) found males of the tortricid *Choristoneura fumiferana* (Clem.) to be consistently photopositive, whereas the females were just as consistently photonegative. Menusan (6) showed that young adults of the bean weevil, *Bruchus objectus* Say, were photonegative, but old adults and spent females became photopositive. Any differences observed in the behaviour of *P. strobi* adults before the photonegative response occurs seem to be in the intensity of the response between individuals, all of which eventually move towards the light. Adults tested after emergence from infested leaders or from hibernation sites are strongly photopositive, whereas freshly fed adults of either age group almost consistently shift their direction of travel one or more times before reaching the light. After a short term of starvation their paths become more direct and regular. Dethier (1) explains this by suggesting that there is a short period of excitation resulting from abrupt removal from the food that interferes with the photopositive response.

Although no sharp distinction was observed between the reactions of fed young or old adults to discrete light, the results with starved adults indicate a definite tendency on the part of the young adults to exhibit weaker photopositive reactions than do the old ones. After 24 hours starvation the difference between the two groups is shown only in the length of time required to reach the light, but with prolonged starvation greater differences appear in the indirectness of the paths as well as in the time required to complete the reaction (tracks 4, 5, and 1, 2, 3, of Fig. 3A and B, respectively). Whereas the initial indifference of the autumn group changes to more direct responses during subsequent trials, the members of the spring population exhibit consistent paths throughout all their trials. In the field, these differences are reflected in the marked differences in behaviour of adults before and after hibernation. During the autumn, adults situated in warm shaded sites may remain there and continue to feed for extended periods of time irrespective of the temperature of the exposed, upper regions of the habitat. One the other hand, during the spring, the survival of the adults is dependent on their ability to remain on the exposed leader, so that they consistently respond photopositively at moderate temperatures.

Reversal of the photic orientation of insects exposed to high temperatures is common. This has been demonstrated with lepidopterous larvae (8, 10), with hymenopterous larvae (3), and with dipterous adults (2, 4), to mention only a few examples. In most cases, as with the white pine weevil, the observed changes in orientation to light at specific temperatures help explain those changes in the behaviour of the insects in the field that normally have a definite survival value.

In laboratory experiments, it has been shown that the level of temperature at which the insects reverse their photic orientation is directly related to their previous conditioning. Fed and starved adults of the autumn and spring populations reverse from positive to negative at correspondingly lower temperatures as the temperature of acclimation is reduced from 20° to 12°C. In addition, at each of these acclimation temperatures the effect of starvation is clearly observed in the general drop in the reversal temperature of the adults. Moreover, there is a greater reduction in the reversal temperature between fed and starved adults of the spring population than between fed and starved members of the autumn

population. Apart from this difference, starvation does not appear to affect further the responses of the adults.

Another aspect of the laboratory investigations merits attention. At 0°C, which is well below the temperature-activity range of the insect[2], no difference was observed in the reversal temperatures of adults during the spring, irrespective of the presence or absence of food. Similar results were obtained during the autumn. When the mean reversal temperatures of the autumn and spring adults were compared, however, they varied significantly. These observations are in line with the results observed between groups kept at higher temperatures, indicating that young adults, which are active during the autumn, are unable to remain positive at temperatures as high as older adults, which are active during the spring, are able to.

Several aspects of the results discussed above have a definite bearing on the behaviour of the adults in the field. The peculiarities of adult behaviour cannot, however, be adequately assessed in the absence of micrometeorological measurements in the insects' habitat. The value of such records in studies of this nature have also been demonstrated earlier (7). In the present study, the field records show that adverse weather conditions ranging above and below the upper and lower limits tolerated by weevil adults occur during their season of activity, but their responses to light and temperature carry them, in exposed stands, to sites with more moderate climates. For example, after a rapid drop in temperature, the warmer temperatures in shaded sites help to explain the presence of the adults at the base of a tree. The subsequent fate of the adults differs, however, in spring and autumn. When the temperature drops during late autumn, the adults driven to the tree bases are prepared for hibernation and therefore suffer few ill effects. After emergence from hibernation the following spring, however, comparable weather prohibits feeding on the leaders and may, if it persists for several days, result in excessive mortality. Examples of the dependence on weather at this time have been reported by MacAloney (5). On the other hand, adults of the autumn group that are overheated at exposed sites move to the shaded cooler locations of the habitat where they continue feeding and, because of their weaker photopositive reaction, do not always attempt to move back to the exposed sites immediately their body temperature drops. In contrast, adults of the spring group have strong enough responses so that their position within their habitat is closely regulated by temperature and light. They are limited to the leading shoot for both feeding and oviposition, and their ability to withstand higher temperatures than autumn adults can permit them to remain at this site over a greater range of high temperatures. When they are finally overheated, they also respond by movement to shaded, cooler areas of the habitat, but their subsequent behaviour consists of attempts to move back to the feeding and oviposition site immediately their body temperature drops in the cooler location.

CONCLUSIONS

1. At room temperature adults of the spring and autumn populations of *P. strobi* are photopositive to discrete sources of light. Starvation simply intensifies the reaction until about 48 hours before death. At this time the insects still respond photopositively, but their paths to the light are more irregular and the time they require to reach the light is increased considerably. Starved adults of the autumn population exhibit weaker photopositive reactions, which are clearly

[2]Discussed in author's thesis, "A Biological Study of the White Pine Weevil, *Pissodes strobi* Peck, with Special Reference to the Effect of Physical Factors on its Activity and Behaviour." Ph. D. Thesis, Macdonald College, McGill University, 1957. The influence of physical factors on the activity of *P. strobi* will be treated in detail in a later paper.

shown by their inconsistent pattern of behaviour after starvation up to 24 hours before death. Their initial trials are marked by extended periods of indifference; these are less evident during subsequent trials. On the other hand, starved spring adults are more strongly photopositive during initial trials and remain so during subsequent trials. After starvation up to five hours before death, both autumn and spring adults become strongly photonegative.

2. At room temperature, fed young and old adults are positive to diffuse light, but become negative when overheated; this reversal also appears in their field behaviour. The temperature at which they reverse varies with their previous temperature conditioning. The main difference between the young and old adults is that the former become negative at *lower* temperatures.

3. When starved and conditioned to temperatures within their normal activity range, adults of both the spring and autumn populations become negative at *lower* temperatures than when fed. Both starved and fed adults conditioned to temperatures below their normal activity range, however, have the same reversal temperature. Age has an effect, since starved adults of the autumn population acclimated to 20 and 0°C become negative at *lower* temperatures than starved adults of the spring population acclimated to similar temperatures. When conditioned to 12°C, there was no statistically significant difference in the temperatures at which young and old adults became negative.

4. In the field, the insects respond to temperature and light in accordance with their observed responses in the laboratory, but adequate assessment of their movements can be made only with an understanding of the micrometeorological aspects of the habitat.

5. The lower reversal temperatures of the autumn population of weevils does not present a hazard to survival. When overheated at exposed points of the habitat the adults move to shaded, cooler points where they may continue to feed. Feeding and oviposition of the spring population is, however, limited to the leader, and their higher reversal temperatures permit them to remain at this exposed site over a greater range of temperature.

SUMMARY

The laboratory reactions of pre-conditioned adults of the white pine weevil, *Pissodes strobi* Peck, to discrete and diffuse light sources and the effect of temperature on these responses are described and used in the interpretation of adult behaviour in the field. Differences in the behaviour patterns of young and old adults in the field are related to measurements of the micrometeorological aspects of their habitat and, when assessed in terms of their observed responses in the laboratory, indicate an efficient means of survival. Young adults during autumn are unable to withstand exposure to habitat climates as extreme as those of the older adults the following spring, but differences in their behaviour patterns that compensate for this indicate that the insects are well adapted to seasonal periods characterized by marked differences in the general climate.

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Definition of the Genus *Grammonota* (Araneae: Erigonidae), with Descriptions of Seven New Species[1]

By C. D. DONDALE[2]

Crop Insect Section, Science Service Laboratory
Kentville, N.S.

Grammonota Emerton, 1882, is one of the many uniform genera that constitute the large and complex family Erigonidae. All of the 28 species and one subspecies recognized by the present writer are American in range, and representatives occur from southwestern Alaska and James Bay in the north to Central America and the West Indies. A few species are arctic-alpine, or are restricted to the Pacific coast, but most occur east of the Rocky Mountains from southern Canada to the Gulf States.

This paper supplements a revision of the genus by Bishop and Crosby (1932) and the more recent catalogue by Bonnet (1957). It is based largely on material in the collections of the American Museum of Natural History in New York. *Grammonota* is redefined on the basis of some new anatomical evidence, new synonomy is given for three species, and seven species are described as new. Holotypes of six of the new species are in the American Museum of Natural History, and that of *G. angusta* new species, with a Canadian type locality, is in the Canadian National Collection in Ottawa. Paratypes, unless otherwise indicated, are in the former institution. The holotype and allotype of *G. chamberlini* Ivie and Barrows and the holotype of *G. trivittata georgiana* Chamberlin and Ivie, all of which had originally been deposited in the University of Utah collection, were redeposited in the American Museum of Natural History.

[1]Contribution No. 3898, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Associate Entomologist.

Grammonota is distinguished from *Ceratinella* Emerton and *Ceraticelus* Simon, to which it is closely related, by the following combination of characters: abdomen without ventral scuta, usually without a dorsal scutum (exceptions: *sclerata* Ivie and Barrows and males of *gigas* (Banks)); dorsal abdominal pattern composed typically of a dark-grey, longitudinal band at the middle line in the anterior half and a series of grey, chevronlike bars posteriorly, but more rarely of one or of three longitudinal bands extending the whole length of the abdomen (as in *vittata* Barrows, *chamberlini*, *nigrifrons* Gertsch and Mulaik, and *trivittata trivittata* Banks) or uniformly grey (as in *inornata* Emerton and *disparata* new species); cheliceral fang normal, with only a single curve; posterior row of eyes usually straight or moderately procurved (exceptions: *insana* (Banks) and *emertoni* Bryant); median ocular area broader behind than in front; tibia IV, and usually tibiae I to III, each with a prominent dorsal spine on the basal half; a single long trichobothrium present on "metatarsi" I to IV, the one on the first leg usually arising from a point nine-tenths the distance from the base of the segment (exceptions: *sclerata*, with the trichobothrium at four-tenths, and *inornata* and *disparata* new species, with the trichobothrium at six-tenths); carapace of male occasionally raised in a large conical hump behind the eyes (as in *pictilis* (O.P.-Cambridge), *angusta* new species, *capitata* Emerton, *subarctica* new species, and *texana* (Banks)), or in a transverse series of lobes (as in *gigas*); dorsolateral apophysis of male palpal tibia little specialized, forming a relatively simple lobe that may, however, be finely bifurcate at the tip (as in *ornata* (O.P.-Cambridge), *maculata* Banks, and *jamaicensis* new species) or spatulate (as in *disparata* new species); embolus of male copulatory organ typically forming an open loop at end of bulb, gradually narrowing to the tip without giving off a distinct tailpiece (exceptions: *suspiciosa* Gertsch and Mulaik and *disparata* new species, in which it is abruptly narrowed and bears a simple tailpiece); tip of embolus occasionally modified as an open spiral of one or a few turns, as in *vittata*, *maritima* Emerton, *gentilis* Banks, and *electa* Bishop and Crosby, or as a compressed coil, as in *pictilis*, *angusta* new species, and *capitata*.

Grammonota pictilis (O.P.-Cambridge, 1875)

Figs. 1, 6, 24

Two sympatric species have been confused under the name *pictilis* for many years. Emerton's (1882) description and figures of *pictilis* are considered correct, but Bishop and Crosby (1932) refer to a specimen from Digby, Nova Scotia, with "a small black tooth on the surface of the tibia" of the palpus. This character fits *angusta* new species, but not *pictilis*. Their illustration of the epigynum of *pictilis* is, in fact, of this new species. I have found that slightly more than half of the specimens that were labelled *pictilis* in the American Museum of Natural History, and all of those similarly labelled in the Canadian National Collection, belong to the new species.

Range.—Minnesota to Nova Scotia, south to Tennessee and North Carolina; California (Chamberlin and Ivie, 1941). Most or all of the previously published records of this species from Canadian localities probably pertain to *angusta*.

Localities.—*Minnesota*: Plummer; Itasca State Park. *New Hampshire*: Pike; Hollis; Three Mile Island, Lake Winnepesaukee. *Massachusetts*: Woods Hole. *Nova Scotia*: New Ross, Lunenburg County; Kentville, Coldbrook Station, Blue Mountain, Rockland, and Canard, all in Kings County. *Connecticut*: Kaston (1948). *New York*: Stamford; Little Pond; Letchworth Park; Valcour Island; Bumps Pond, Washington County; Trenton Falls; Ithaca; Fortsville. *West*

B & Z Library

Virginia: Gaudineer Knob, two miles east of Cheat Bridge. *North Carolina*: Highlands, Macon County. *Tennessee*: Kingston.

Grammonota angusta new species

Figs. 2, 7, 14, 23

Male.—Total length about 2.7 mm.; cephalothorax 1.2 mm. long and 0.8 mm. wide. Carapace, palpi, and chelicerae yellow-brown, the margins and some lines that radiate from the dorsal groove darker. Legs and distal lobes of pedipalp coxae yellowish. Sternum grey-brown. Abdominal pattern normal for genus. Venter of abdomen pale grey.

Carapace, viewed from the side, ascending from the posterior margin to the base of the carapace hump in a nearly straight line, interrupted by a slight prominence at the dorsal groove (Fig. 14). Carapace hump in the shape of a low, blunt cone. Median ocular area convex, clothed with stiff, recurved hairs. Front nearly straight, slightly protruding at the distal margin.

Tibia of palpus armed dorsolaterally with a large apophysis, at the base of which is a sharp tooth on the dorsal surface (Fig. 7); a second, smaller tooth at middle of distal margin. Embolus long, terminating in a flat coil of three turns (Fig. 2).

Female.—Total length 2.7 to 3.5 mm.; cephalothorax 1.2 to 1.4 mm. long and 0.9 mm. wide. Colouration essentially as in male. Epigynum consisting of a posterior transverse plate, in front of which lies a pair of round openings (Fig. 23); anterior margin raised in the form of a nipplelike protuberance; two strongly sclerotized coils of internal duct visible through integument on each side.

Diagnosis.—This species is very similar in general appearance to *pictilis* and *capitata*. In males of all three species the carapace has a conical hump, and the embolus terminates in a compressed coil. All are found in coniferous trees. The best characters for separating *angusta* from *pictilis* and *capitata* are found in the external male genitalia, of which the terminal coil of the embolus contains three turns in *angusta* and four in the other two species. The palpal tibia of *angusta* also bears a tooth at the base of the dorsolateral apophysis (Fig. 7), whereas that of *pictilis* (Fig. 6) and of *capitata* does not. In females, the epigynum differs in structure between *angusta* (Fig. 23) and *pictilis* (Fig. 24), but females of *capitata*, which Emerton (1924) stated to be inseparable from *pictilis* on the basis of this structure, were not seen in the present study.

Type Locality.—Scott's Bay, Kings County, Nova Scotia.

Type Material.—Holotype, male, and allotype, female (No. 6492), and three male and six female paratypes (No. 6804) from the type locality, June 13, 1957 (C. D. Dondale), deposited in the Canadian National Collection; five male and 13 female paratypes from Centreville, Kings County, Nova Scotia, June 13, 1957 (C. D. Dondale), in the American Museum of Natural History; one male and one female paratype from Ottawa, Ontario, June 17, 1916 (J.W.A.), in the Canadian National Collection; 10 male and 20 female paratypes from Forest Hill, near Gaspereaux, Kings County, Nova Scotia, June 12, 1957 (C. D. Dondale), in the Science Service Laboratory, Kentville, N.S.

Other Localities:—*South Dakota*: Sheridan Lake, Black Hills; Game Lodge, Custer State Park. *Manitoba*: The Pas. *New York*: Indian Lake; Wawbeek, Franklin County. *Ontario*: Lake Temagami; Cochrane. *Quebec*: Bagotville, Hébertville; Percé. *Labrador*: "Southern Labrador"; Muskrat Falls, Hamilton River. *Newfoundland*: St. Fintan's. *Prince Edward Island*: Tracadie; Wood Island. *Nova Scotia*: Digby; Cape Blomidon; Blue Mountain, Kings County; Annapolis Royal; Granville Ferry; Cow Bay, Halifax County; Lockeport; Hebb-

ville, near Bridgewater; Sweet's Corner, Hants County; Lunenburg. *New Brunswick*: Green River. *Maine*: Mount Desert Island; Sebasticook Lake; Falmouth; Winterport; Island Falls; Houlton.

***Grammonota ornata* (O.P.-Cambridge, 1875)**

Grammonota bidentata Emerton, 1926, Can. Ent. 58: 117, Fig. 6. New synonomy.

Bishop and Crosby (1932), who had not examined specimens of *bidentata* at the time they published their revision, thought it to be identical with *maculata* Banks. The type localities of *bidentata*, however, lie outside the range of *maculata*, which is a southern species. Two males and a female in the Canadian National Collection, labelled *bidentata* Emerton, Sharon, Massachusetts (one of the type localities for *bidentata*), June 12, 1924, were compared with *ornata* from Connecticut and New York and found to be identical with them. Emerton's (1926) illustrations of *bidentata* also agree with *ornata*.

Range.—Illinois to Massachusetts, south to North Carolina.

Localities.—Illinois: Champaign. *Michigan*: Ann Arbor. *New York*: Beaver Kill; Montauk Point; Clove Valley, Staten Island; Long Branch. *Connecticut*: Kaston (1948). *New Jersey*: Ramsey; Mays Landing.

***Grammonota trivittata* Banks, 1895**

This is an Atlantic coast species. Specimens from the northern part of its range agree well with Bishop and Crosby's (1932) description: the abdominal pattern consists of a median and two lateral grey bands, in some cases with a few indistinct transverse bars at the posterior extremity. Males from Massachusetts and Connecticut have a total length of 2.0 to 2.1 mm. and a carapace length of about 1.1 mm. In contrast, specimens from New Jersey, North Carolina, and Georgia have a different pattern and are smaller. These southern specimens are typified by the male holotype of *G. georgiana* Chamberlin and Ivie, in which the abdominal pattern is complete with a series of transverse bars posteriorly, and the total length and carapace length are 1.9 mm. and 1.0 mm. respectively (Chamberlin and Ivie, 1944). In other respects, e.g., shape of carapace and details of the male palpus and female epigynum, *trivittata* and *georgiana* appear to be identical. Since most araneologists consider similarity of external genitalia an important criterion for conspecificity in spiders, the name *georgiana* is here applied to the southern population of *trivittata*, with subspecific rank. Specimens from Long Island, New York, appear to be intermediate in size and in abdominal pattern, but a larger series of specimens is needed to confirm this.

***Grammonota trivittata trivittata* Banks, 1895**

Range.—Maine south along the coast to Connecticut.

Localities.—Massachusetts: Wellfleet. *Connecticut*: Kaston (1948).

***Grammonota trivittata georgiana* Chamberlin and Ivie, 1944, new combination**

Grammonota georgiana Chamberlin and Ivie, 1944, Bull. Univ. Utah 35 (9) (Biol. Series 8 (5)): 26, 72, Figs. 130, 131.

Grammonota trivittata, Barnes, 1953, American Mus. Novitates, No. 1632: 10.

Type Locality.—Savannah Beach, Georgia.

Range.—New Jersey to Georgia.

Localities.—New Jersey: Oceanville. *North Carolina*: Barnes (1953). *Georgia*: Savannah Beach (holotype male of *georgiana*).

***Grammonota texana* (Banks), 1899**

Grammonota gallinoides Barnes, 1953, American Mus. Novitates, No. 1632: 8, Figs. 5-8. New synonomy.

This common species is variable in colour. Specimens from Florida and from North and South Carolina are usually pale, and the abdominal pattern may be

reduced to a short, median grey band on a pale background. Many Texas specimens, on the other hand, have a pattern like that of the more typical species in the genus. The allotype female and a male paratype of *gallinoides* were compared with a large series of *texana*, and the former are considered to be well within the range of structural variability of the latter.

Range.—Mexico. Texas to Florida, north to New Jersey.

Localities.—Mexico: Acapulco; Reynosa; Hidalgo. *Texas*: Ben Bolt; Temaho; Livingston; McAllen; Brownsville; Red Gate; Riesel; San Manuel; Alfred, north of Alice; Encino; Leesburg; Corpus Christi; Edinburg; San Antonio; Houston; Maud; Llano. *Louisiana*: Jennings; Shreveport; Ruston. *Arkansas*: Hope. *Mississippi*: Ocean Springs; Gulfport; Hattiesburg; Biloxi; Pass Christian. *Tennessee*: Kingston. *Alabama*: Pickett Springs; Arcola. *Florida*: Lake Placid; Blount's Ferry; Pensacola; Clearwater; Maples, Collier County; Gainesville; Micanopy; Arcadia; Old Town; Lake Jackson; Sebring; Orlando. *Georgia*: Thunderbolt; Wadley. *South Carolina*: McClellanville. *North Carolina*: Beaufort; Davidson; Bogue Bank (allotype female and male paratype of *gallinoides*). *New Jersey*: Cape May.

Grammonota barnesi new species

Figs. 3, 10, 13, 20

Male.—Total length about 2.3 mm.; cephalothorax 1.6 mm. long and 1.1 mm. wide. Carapace dark reddish-brown. Sternum and appendages light orange-brown. Abdominal pattern normal for the genus. Venter of abdomen light grey.

Carapace, viewed from the side, evenly rounded from the posterior margin to the dorsal groove, and with a low, broad prominence behind the posterior eye row (Fig. 13). Median ocular area occupied by a tuft of short, stiff, recurved hairs. Front convex, nearly vertical.

Tibia of palpus armed with a dorsolateral apophysis, near the base of which is a slender, curved tooth on the dorsal side (Fig. 10). Embolus simple and very slender distally (Fig. 3).

Female.—Total length 2.4 to 2.9 mm.; cephalothorax 1.1 to 1.3 mm. long and 0.8 mm. wide. Colouration as in the male. Epigynum penetrated anteriorly by a long, sinuous, median canal (Fig. 20).

Diagnosis.—In size and colour this species resembles two of the more northerly species, *inornata* and *inusiata* Bishop and Crosby. It is readily separated from both, however, by the presence of a tooth at the base of the dorsolateral apophysis of the male palpal tibia, and a deep, sinuous canal in the anterior portion of the epigynum. The species is named in honour of Dr. R. D. Barnes, who has collected and studied extensively many of the spiders of North Carolina in recent years.

Type Locality.—Davidson, Mecklenburg County, North Carolina.

Type Material.—Holotype, male, and one male paratype from the type locality, Oct. 31, 1941. Allotype, female, and four female paratypes from Eastern Branch, near Bennings, District of Columbia, Feb. 23, 1913 (Shoemaker).

Grammonota sclerata Ivie and Barrows, 1935

Fig. 17

Grammonota confusa Gertsch and Mulaik, 1936, American Mus. Novitates, No. 863: 3, Figs. 4, 5. New synonomy.

This species is variable in colour. The carapace varies from pale brown to nearly black on the anterior part, and from pale yellow to dark orange posteriorly. The abdomen ranges from pale, off-white to dark grey. This is the only species in the genus in which both sexes have an abdominal scutum. This scutum is restricted to the anterior declivity of the abdomen in females, and to the mid-

dorsal region of the anterior half of the abdomen in males. The only other member of the genus *Grammonota* that has an abdominal scutum is the male sex of *gigas* (Banks), in which this structure is much broader (Bishop and Crosby, 1932).

G. sclerata is also unusual in that the dorsal trichobothrium on "metatarsus" I arises from a point about four-tenths the distance from the base of the segment. This position of the trichobothrium is typical of *Ceratinella* (Denis, 1948; Locket and Millidge, 1953), as is the presence of an abdominal sclerite, but *sclerata* is retained in *Grammonota* because it has the typical male palpus of this genus.

Type Locality.—Fort Myers, Florida.

Range.—Mexico. Texas to Florida, north to New Jersey.

Localities.—Mexico: Reynosa; San Pedro. *Texas*: Rio Grande City (holotype male of *confusa*); Laredo; Oakhurst. *Mississippi*: Pass Christian. *Florida*: Fort Myers (female paratype of *sclerata*). *North Carolina*: Barnes (1953). *New Jersey*: Lakewood.

Grammonota disparata new species

Figs. 5, 11, 16, 19

Male.—Total length about 1.9 mm.; cephalothorax 0.8 mm. long and 0.7 mm. wide. Carapace dark brown, with a dusky, shield-shaped area in front of the dorsal groove, and dusky radiating lines. Appendages pale yellow-brown. Sternum grey-brown. Abdomen dark grey, with very narrow, white, transverse lines on the dorsum posteriorly.

Carapace, viewed from the side, ascending rather steeply from behind to the dorsal groove, then less steeply and in a slightly depressed line to a small prominence behind the posterior median eyes (Fig. 16). Front slightly convex and protruding distally.

Tibia of the palpus armed with a long, spatulate dorsolateral apophysis (Fig. 11). Embolus abruptly narrowed distally, giving off a small tailpiece (Fig. 5).

Female.—Total length about 2.7 mm.; cephalothorax 1.1 mm. long and 0.8 mm. wide. Colouration as in the male. Epigynum with a broad transverse plate that is shallowly indented anteriorly, and with a pair of sclerotized rods laterally (Fig. 19).

Diagnosis.—This species resembles *suspiciosa* in colour, but is larger than that species. In both, the embolus is atypical for the genus, being abruptly narrowed rather than tapering. The dorsolateral apophysis, which is spatulate in *disparata* new species, permits separation of males of the two species. The paired internal sclerotic rods of the epigynum are characteristic of *disparata* new species. Like *inornata*, this species has the "metatarsal" trichobothrium at six-tenths the distance from the base of the segment.

Type Locality.—McKay's Peak, White Mountains, Arizona.

Type Material.—Holotype, male, allotype, female, from the type locality, July 10, 11, 1940 (Gertsch and Hook).

Grammonota jamaicensis new species

Figs. 8, 15, 18

Male.—Total length 1.75 mm.; cephalothorax 0.84 mm. long and 0.64 mm. wide. Carapace orange-brown, with that portion in front of the dorsal groove distinctly paler. Sternum and appendages yellow-brown, except the coxae, trochanters, and basal parts of the femora, which are pale. Abdominal pattern normal for the genus.

Carapace, viewed from the side, ascending from behind in a convex curve to the dorsal groove, then nearly horizontally for a short distance, and forming a

low prominence, which bears a dense tuft of long, forward-curved setae, just behind the posterior median eyes (Fig. 15). Eyes normal for the genus. Median ocular area slightly convex, clothed with short, backward-curved setae.

Tibia of palpus expanded distally (Fig. 8); dorsolateral apophysis slender, slightly longer than broad, and terminating in two minute points. Embolus normal. The foregoing description is based on the allotype male, on which the following injuries should be noted: legs I and II on the left side are each reduced to the coxa and trochanter, the chelicerae are displaced backward slightly, and many of the leg spines and hairs have been rubbed away.

Female.—Total length, based on seven specimens, 1.89 to 2.24 mm.; cephalothorax 0.83 to 0.85 mm. long and 0.63 mm. wide. Colouration essentially as in the male. Posterior transverse plate of epigynum, at the anterior margin of which lie the paired openings, about as long as broad, slightly narrowed in front (Fig. 18). Anterior margin of epigynum with a pigmented, crescent-shaped mark.

Diagnosis.—In size, shape of carapace, and general colouring this species resembles the Central American species *electa*. It differs from the latter in having two distinct colour areas on the carapace, a condition suggestive of *sclerata* and of *semipallida* Emerton. It also has a much smaller tibial apophysis on the male palpus, and a different epigynum. From *maculata* this species can be separated by its smaller size, the arrangement of the setae on the dorsal prominence of the male carapace in a dense tuft, a much less distinct bifurcation in the tibial apophysis of the male palpus, and by details of the epigynum.

Type Locality.—Hardwar Gap, Jamaica.

Type Material.—Holotype, female, allotype, male, and six female paratypes from the type locality, December 6, 1954 (A. M. Nadler).

Grammonota gentilis Banks, 1898

This species is included here because certain new locality data reveal an unusually extended range for a species of *Grammonota*. Despite this large range, however, no evidence was obtained for division of the species into geographic subspecies.

Range.—Alberta to James Bay, south along the Rocky Mountains to Mexico.

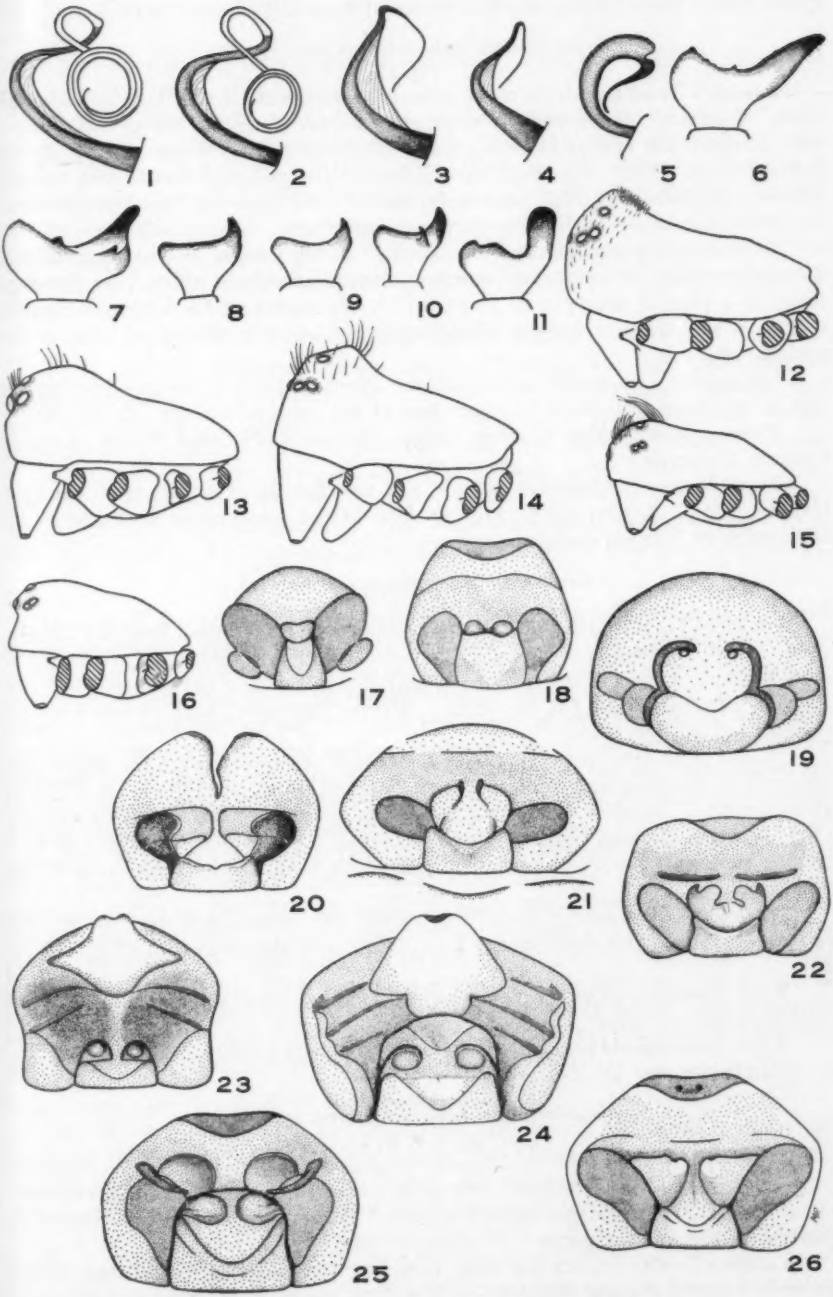
Localities.—Alberta: Sebee. *Saskatchewan*: Saskatoon. *Montana*: Billings. *Minnesota*: Itasca State Park. *Wyoming*: Yellowstone Lake. *Colorado*: Regnier; West Lake Camp Ground, northwest of Fort Collins; Ranch Sawatch, Beuna Vista; Wolf Creek Pass; Buffalo Lake, near Victor. *Utah*: Wahwah Springs. *New Mexico*: Sante Fe; Camp Mary White, Otero County; Sand Springs. *Arizona*: White Mountain Research Station, east of McNary; Painted Canyon Ranch, west of Portal; Southwestern Research Station, west of Portal;

Figs. 1-26. *Grammonota* spp. 1-5. Emboli of males. 1, *G. pictilis*. 2 *G. angusta* new species. 3, *G. barnesi*, new species. 4, *G. subarctica* new species. 5, *G. disparata* new species.

6-11. Tibiae of male palpi, dorsal views. 6, *G. pictilis*. 7, *G. angusta* new species. 8, *G. jamaicensis* new species. 9, *G. subarctica* new species. 10, *G. barnesi* new species. 11, *G. disparata* new species.

12-16. Carapaces of males, lateral views. 12, *G. subarctica* new species. 13, *G. barnesi* new species. 14, *G. angusta* new species. 15, *G. jamaicensis* new species. 16, *G. disparata* new species.

17-26. Epigyna of females. 17, *G. sclerata*. 18, *G. jamaicensis* new species. 19, *G. disparata* new species. 20, *G. barnesi* new species. 21, *G. subarctica* new species. 22, *G. kincaidi*. 23, *G. angusta* new species. 24, *G. pictilis*. 25, *G. coloradensis* new species. 26, *G. zephyra* new species.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Lake Mary; Black River, White Mountains, at 7,800 feet elevation. *Mexico*: Cerro Potosi, Neuvo Leon; Saltillo; crater of Mount Toluca.

Grammonota coloradensis new species

Fig. 25

Female.—Total length 2.6 to 2.8 mm.; cephalothorax 1.3 mm. long and 0.9 mm. wide. Carapace orange-yellow, with a light-grey mark at the dorsal groove, grey margins, and orange radiating lines. Sternum and chelicerae orange, lightly suffused with grey. Legs and distal lobes of the pedipalp coxae pale orange-yellow. Abdomen marked anteriorly and at the sides by grey longitudinal wrinkles; posteriorly with faint, grey transverse bars. Venter pale grey.

Ventral spines on tibia and "metatarsus" of leg I all of nearly equal length. Transverse plate of epigynum deeply indented anteriorly (Fig. 25); openings lying in a pair of nearly oval areas, which are separated by a narrow median septum. The anterior margin of the epigynum with a sclerotized area at the middle line.

Diagnosis.—This species is like *kincaidi* (Banks) and *zephyra* new species, but can be separated from these by characters of the epigynum (Figs. 22, 25, 26).

Type Locality.—Rist Canyon Camp, Roosevelt National Forest, Larimer County, Colorado.

Type Material.—Holotype, female, and two female paratypes from the type locality, June 7, 8, 1947 (C. C. Hoff). One of the paratypes is deposited in the University of Utah collection.

Grammonota zephyra new species

Fig. 26

Female.—Total length about 2.7 mm.; cephalothorax 1.3 mm. long and 1.1 mm. wide. Carapace orange-brown with grey radiating lines. Sternum and chelicerae orange-grey. Legs and distal lobes of pedipalp coxae pale orange-yellow. Abdominal pattern normal for the genus. Venter pale grey, with darker lines extending toward the sides.

Tibia I with two pairs of ventral spines that are about twice the length and diameter of the remaining ventral spines. Ventral spines of the "metatarsi" all of equal lengths. Posterior transverse plate of epigynum deeply indented anteriorly (Fig. 26); the openings lying in paired triangular areas, which are separated by a median septum. Anterior margin of epigynum with a sclerotized area at the middle line.

Diagnosis.—This species resembles *kincaidi* and *coloradensis* new species, but can be separated from these species by characters of the epigynum (Figs. 22, 25, 26).

Type Locality.—Arlington, Snohomish County, Washington (122° 8′ west longitude, 40° 10′ north latitude).

Type Material.—Holotype, female, from the type locality, Sept. 11, 1935 (R. V. Chamberlin and W. Ivie).

Grammonota subarctica new species

Figs. 4, 9, 12, 21

Male.—Total length 2.3 to 2.6 mm.; cephalothorax 1.1 to 1.3 mm. long and 0.9 to 1.0 mm. wide. Carapace orange-brown with darker dorsal groove and radiating lines. Appendages orange-yellow. Sternum light orange. Abdominal pattern normal for the genus. Venter pale grey.

Carapace, viewed from the side, ascending from behind to the base of the hump in a nearly straight line, with only a slight prominence at the dorsal groove (Fig. 12). Hump of carapace in the form of a low cone, the posterior slope

densely clothed with short, curved, grey hair; the anterior slope continuing to the front without any intervening constriction. Front slightly convex and nearly vertical.

Palpal tibia armed with a large dorsolateral apophysis (Fig. 9). Embolus very slender distally (Fig. 4).

Female.—Total length 2.8 to 3.4 mm.; cephalothorax 1.3 to 1.4 mm. long and 1.0 to 1.1 mm. wide. Colouration essentially as in the male, although in most females the carapace is more deeply pigmented and the abdominal pattern is relatively more extensive. Transverse plate of epigynum rather deeply indented anteriorly (Fig. 21).

Diagnosis.—This species differs from others in the genus in the shape of the male carapace and in the kind and arrangement of setae thereon. The epigynum of the female also differs (Fig. 21).

Type Locality.—Etolin Island, Menefee Inlet, Alaska.

Type Material.—Holotype, male, allotype, female, and nine male and 11 female paratypes from the type locality, Sept. 21, 1951 (B. Malkin), one male and one female retained in the Science Service Laboratory, Kentville, N.S. Other paratypes from Alaska as follows: two males and three females, Crittenden Creek, 10 miles east of Wrangell, Sept. 20, 1951 (B. Malkin), in the University of Utah collection. Four males and five females, Prince of Wales Island, Red Bay, Alaska, Sept. 14, 1951 (B. Malkin). One female, Southeast Wrangell, Sept. 1-20, 1951 (B. Malkin). Two females, Mole Harbour, Sept. 24, 1932 (A. Hasselborg).

Summary

Spiders of the genus *Grammonota* Emerton occur from southeastern Alaska and James Bay to Central America and the West Indies. The genus is redefined, mainly on the absence of abdominal scuta, the nature of the colour pattern on the dorsum of the abdomen, the position of the dorsal tibial spine and "metatarsal" trichobothrium on leg IV, and the shape of the embolus of the male copulatory organ. Seven new species are described. *G. angusta* n. sp. has been confused in the past with *G. pictilis* (O.P.-Cambridge), but the two species are readily separated by characters of the internal genitalia. Of the other new species, *barnesi* is described from Davidson, North Carolina and from the District of Columbia, *disparata* from the White Mountains in Arizona, *jamaicensis* from an inland locality in Jamaica, *coloradensis* from Roosevelt National Forest in Colorado, *zephyra* from Arlington, Washington, and *subarctica* from the coast of southeastern Alaska. *G. bidentata* Emerton becomes a synonym of *G. ornata* (O.P.-Cambridge), *G. gallinoides* Barnes a synonym of *G. texana* (Banks), and *G. confusa* Gertsch and Mulaik of *G. sclerata* Ivie and Barrows. *G. georgiana* Chamberlin and Ivie becomes a subspecies of *G. trivittata* Banks. An unusually extended range is shown for *G. gentilis* Banks, which occurs from Alberta and James Bay south along the Rocky Mountains to Mexico.

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Dr. W. J. Gertsch, Curator, Department of Insects and Spiders, American Museum of Natural History, freely placed the Museum's collection of *Grammonota* spp. at my disposal for this study. He also indicated as undescribed the two species described here as *barnesi* new species and *subarctica* new species, and criticized the systematics of the paper. Dr. R. V. Chamberlin, Department of Zoology, University of Utah, kindly contributed the holotype and allotype of *G. chamberlini*, the holotype of *G. trivittata georgiana*, and the specimen used in describing *G. zephyra* new species.

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Synopsis of the Genus *Semium*, and Description of a New Species from Mexico (Hemiptera : Miridae)[1]

By Leonard A. Kelton[2]
Insect Systematics and Biological Control Unit
Entomology Division, Ottawa, Canada

Semium was described by Reuter (1875) and placed in the division Cyllocoraria of the subfamily Capsina. Reuter (1910) later changed the subfamily Capsina to Heterotomina, and the division Cyllocoraria to Halticaria. Van Duzee (1916) changed Reuter's Heterotomaria to Orthotylinae, and placed *Semium* in the division Orthotylaria, tribe Orthotylini. Knight (1923) proposed the tribe Semiini for the genus, but Carvalho (1955) rejected this arrangement and placed the genus in the Orthotylini. Studies on the female and male genitalia by Slater (1950) and Kelton (1959) suggested that the genus is referable to the Phylinae. In this paper the genus is transferred from the Orthotylinae to the Phylinae, tribe Phylini, on the basis of the male and female genitalia and the tarsal claws.

Semium remained monobasic until Knight (1927) described a second species of the genus, *Semium subglaber* Knight, from Arizona and Colorado. In the present paper a third species of this rather peculiar genus is described.

Semium Reuter, 1875

Type species of genus: *Semium hirtum* Reuter, 1875.

The genus is distinguished by the slender claws and the slender, hairlike arolia; the distinct suture on the pronotum separating the lateral area from the dorsal portion; the raised basal portion of the pronotum; and the distinctive membranous pattern on the head, pronotum, and scutellum.

The genitalia of the species are very similar to those of the Phylini and suggest a closer relationship to that tribe than to the Orthotylini. The claspers and the vesica are similar in form to those of the Phylini, and distinctly different

[1]Contribution No. 3881, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Associate Entomologist.

from those of the Orthotylini (Kelton, 1959). The female genitalia are also similar to those of the Phylinae (Slater, 1950). The arolia, however, are somewhat flattened, and parallel or slightly convergent, resembling the type found in the Orthotylinae. The pseudarolia are absent.

Within the Phylini, as suggested by the male genitalia (Kelton, 1959), the species are allied to those of *Monosynamma, Campylomma, Chlamydatus, Conosthethus,* and *Macrotylus.*

Key to Species of *Semium* Reuter

1. Pronotum red or reddish-yellow; hemelytra black; length 3.5 mm. or more ..... *S. rubronotum* n. sp.
   Pronotum black with pale areas; hemelytra black with large white areas; length less than 3.5 mm. 2
2. Pronotum and hemelytra densely pubescent, the hair long and erect; length 2.8 mm. or more ..... *S. hirtum* Reut.
   Pronotum and hemelytra almost glabrous; length less than 2.8 mm. ..... *S. subglaber* Kngt.

Semium hirtum Reuter, 1875

Figs. 1, 4

Distinguished by the colour pattern on the hemelytra, and the dense, erect pubescence on the pronotum and hemelytra.

Male:—Length, 2.8-2.94 mm.; width, 0.88-1.05 mm. Head: width, 0.59-0.61 mm.; vertex, 0.31-0.35 mm.; head nearly vertical, dark brown; membranous areas depressed, pale reddish. Antenna: I, 0.21-0.24 mm., red; II, 0.84-0.91 mm., reddish-brown; III, 0.73-0.75 mm., brown; IV, 0.36-0.38 mm., brown. Rostrum 0.77 mm. long, reaching second coxa. Pronotum 0.49 mm. long, 0.91 mm. wide; apex and side reddish-yellow; basal half velvety brown; pubescence long and erect, very dense. Scutellum rosy-pink, pubescent; ridge along each lateral margin black, forming a V. Hemelytra black, with characteristic white pattern; pubescence long and erect. Legs reddish. Genitalia as illustrated.

Female:—Length, 2.8-3.22 mm.; width, 0.98-1.19 mm. Form and coloration similar to those of the male.

The species is known to feed on spurges (*Euphorbia* spp.). Specimens taken at Champaign, Ill., by J. F. McAlpine were collected under leaves of knotweed (*Polygonum* sp.?) growing in a backyard garden.

Known distribution:—California, District of Columbia, Illinois, Indiana, Iowa, Kansas, New Jersey, New York, Ohio, Pennsylvania, and Texas.

Semium subglaber Knight, 1927

Figs. 2, 5

Distinguished by the colour pattern on the hemelytra, the small size, the banded femora, and the very short and sparse pubescence.

Male:—Length, 2.31-2.73 mm.; width, 0.84-0.98 mm. Head: width, 0.57-0.63 mm.; vertex, 0.31-0.35 mm.; coloration and sculpturing similar to those of *hirtum.* Antenna: I, 0.17-0.21 mm., reddish; II, 0.31 mm., brown. Rostrum 0.75 mm. long, reaching second coxa. Pronotum 0.49-0.59 mm. long, 0.84-0.98 mm. wide; grey with a pink tinge; raised lines of sculpturing dark; pubescence very short, appressed. Scutellum dark, with a number of pinkish membranous depressions. Hemelytra dark brown, with characteristic white pattern; pubescence short and sparse, appressed. Legs generally with paler areas; hind femur with basal two-thirds pale, apex black; corresponding pale areas on middle femora obscured. Genitalia as illustrated.

Female:—Length, 2.66 mm.; width, 1.22 mm. Form and coloration very similar to those of the male.

The species is known to feed on spurge (*Euphorbia* sp.). Specimens taken at Blythe, Fish Creek Mts., and Thousand Palms, Calif., by W. R. M. Mason and W. R. Richards were collected under desert sand-mat (*Euphorbia* sp.).

Known distribution:—Arizona, California, and Colorado.

Semium rubronotum n. sp.

Figs. 3, 6

Distinguished by the reddish-orange pronotum, the black hemelytra, the elongate form, and the black legs.

Male:—Length, 3.5 mm.; width, 1.05 mm. Head: width, 0.7 mm.; vertex, 0.28 mm.; length, 0.26 mm.; head black, the depressions pale orange. Antenna: I, 0.38 mm., black; II, 1.05 mm., black; III, 1.4 mm., dark brown; IV, 0.52 mm., dark brown. Rostrum 0.87 mm. long, almost reaching hind coxa. Pronotum 0.56 mm. long, 0.98 mm. wide; reddish-orange, the depressed areas pale; calli, anterior margin, and longitudinal line at middle, black; pubescence very sparse and short, appressed; several long, black, erect bristles on anterior half. Scutellum black; windows membranous, pale; several stiff bristles, black. Hemelytra dark brown to black; pubescence short and appressed, intermixed with few erect, black bristles. Abdomen and legs dark brown to black. Genitalia as illustrated.

Female:—Slightly larger and more robust than the male, but coloration and pubescence very similar. Length, 3.78 mm.; width, 1.22 mm. Head: width, 0.7-0.75 mm.; vertex, 0.35-0.38 mm. Antenna: I, 0.31 mm.; II, 1.05-1.19 mm.; III, 1.43 mm.; IV, 0.52 mm. Pronotum 0.63 mm. long, 0.99 mm. wide. Genitalia not dissected.

Holotype:—Female, Xilitla, 1,800 ft., San Luis Potosi, Mexico, July 24, 1954; J. G. Chillcott. No. 6790 in Canadian National Collection of Insects, Ottawa.

Allotype:—Male, same data as for holotype.

Paratypes:—Female, taken with the type; female, Cuernavaca, 12 mi. E. Morelos, Mexica, 4,300 ft., Aug. 14, 1954; J. G. Chillcott; two males, 4 mi. W., Tlapacoyan, Vera Cruz, Mexico, Aug. 17, 1958; H. F. Howden. In the Canadian National Collection of Insects, Ottawa, and United States National Museum, Washington, D.C.

Summary

The genus *Semium* Reuter, 1875, with two previously known species, is transferred from the Orthotylinae to the Phylinae, tribe Phylini, on the bases of the male and female genitalia. External characteristics of the genus, a key to species, and the relationships suggested by the genitalia are given. The two previously known species are redescribed; *S. hirtum* is known from California to New York and *S. subglaber* from western United States; the two species feed on spurges, *Euphorbia* spp. A new species from Mexico, *S. rubronotum*, is described.

Acknowledgments

I wish to express my sincere thanks to the following for loaning specimens for study: Dr. W. G. Byers, Snow Entomological Museum, University of Kansas, Lawrence; Dr. J. L. Laffoon, Iowa State College, Ames; and Dr. R. I. Sailer, United States National Museum, Washington, D.C.

Figs. 1-3 Adults of *Semium* spp.

Figs. 4-6. Male genitalia of *Semium* spp.: a, left clasper, dorsolateral view; b, right clasper, lateral view; c, vesica, right lateral view; d, phallotheca, dorsal view.

1

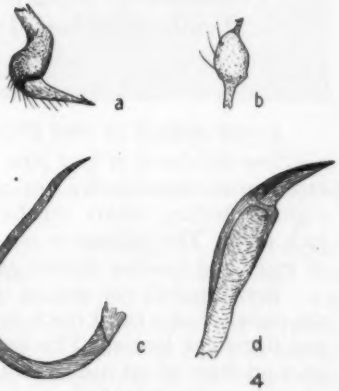
S. HIRTUM

2

S. SUBGLABER

3

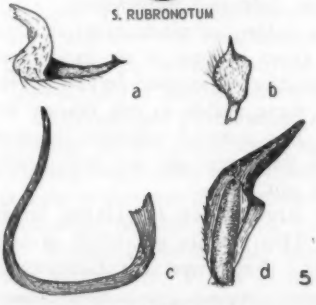
S. RUBRONOTUM



a b c d

4

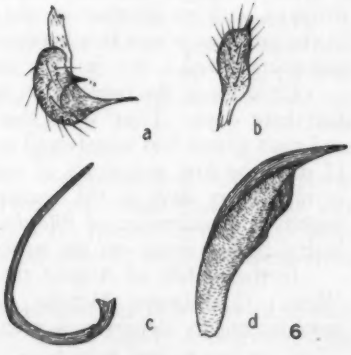
S. HIRTUM



a b c d

5

S. SUBGLABER



a b c d

6

S. RUBRONOTUM

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Predators of *Neodiprion swainei* Midd. (Hymenoptera: Tenthredinidae) Larval Vectors of Virus Diseases[1]

By W. A. Smirnoff

Forest Biology Laboratory, Quebec, P.Q.

In the summer of 1958 a virus disease of larvae of *Neodiprion swainei* Midd., a serious defoliator of jack pine (*Pinus banksiana* Lamb.), was investigated. The experiments were carried out near St. David de Falardeau in the Lake St. John region, Quebec, where the forest is largely composed of 15- to 20-year-old jack pine. The infestation was three years old, and judging by the production of eggs, had reached serious proportions in some places.

Between July 20 and 26 mass hatching of eggs occurred. Simultaneously the presence of a small black hemipteron was noticed in the colonies of neonatal and first-stage larvae. This hemipteron, *Pilophorus uhleri* (Knight), proved to be a predator of neonatal, first-, and second-stage larvae. There was an average of one or two *Pilophorus* in each *N. swainei* colony.

After the larvae had reached the third instar the number of *Pilophorus* dropped, and an increase in the incidence of virus-infected larvae was noted in the colonies where this hemipteron had occurred. Infected larvae characteristically showed a loss in their ability to perform defensive movements.

Eighteen of the hemipteron were placed in a colony of virus-infected larvae for three days. They were then divided into three groups of six individuals, and each group was transferred to a colony of healthy *N. swainei* larvae. After 15 days the first symptoms of the virus diseases were visible in one colony and in nine more days in the remaining colonies. The control colonies remained healthy. Examination of *Pilophorus* collected in the forest did not reveal polyhedral bodies either on the proboscis or in the gut.

In the middle of August the appearance of large brown *Platylygus luridus* (Reut.) (Hemiptera: Miridae) was observed. This species occurred in large numbers but its activity as a predator is not clear. Ants, especially *Camponotus*

[1]Contribution No. 512, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

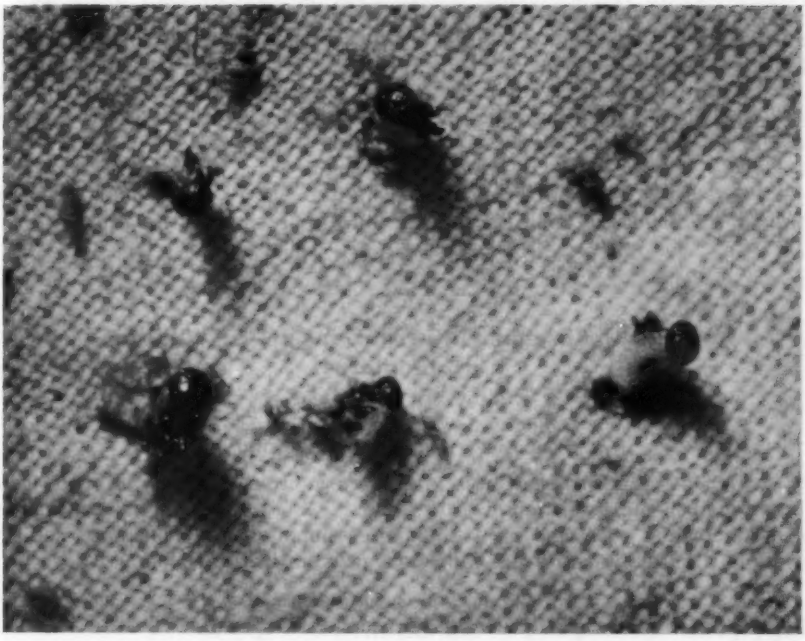

Fig. 1. Larvae of *Neodiprion swainei* Midd. "glued" to the cloth by *Vespula* sp.

herculeanus (Linn.), were observed to carry away dead or weak larvae but did not touch decaying larvae.

The most active predators proved to be wasps. Although *Vespula vulgaris* (Linn.) was present only in small numbers, *Vespula rufa consobrina* (Saus.) was present in large numbers from August until the second half of September. On sunny days this wasp was very active around the defoliated branches of pines. On such branches the larvae deprived of food were weakened and had started to wander in search of new food. The weak, hungry larvae had lost their ability to perform defensive movements and became easy prey for the wasps. The wasps were also very active around the virus-infected colonies, where the diseased larvae had also lost their ability to perform defensive movements. An interesting phenomenon was repeatedly observed on cloths spread underneath infected colonies to facilitate mortality counts (Fig. 1). A wasp caught a weak larva and tore off its abdomen, simultaneously "gluing" the anterior half vertically to the surface of the cloth. Such halves of larvae were also found "glued" to the needles, branches, and bark of jack pine.

Microscopic examination of wasps revealed the presence of virus polyhedra on some mouth parts but none in the gut. However, when whole wasps were crushed, suspended in distilled water and fed to *N. swainei* larvae, the characteristic symptoms of the virus infection appeared after 12 days and some larvae died after 18 days.

In an area where only healthy larvae were present the following experiment was performed. Pieces of fresh meat smeared with a highly concentrated suspension of polyhedra (2.4×10^6 per ml.) were hung from the foliage and wasps were observed to feed on them. After one month several larvae were found

dead of polyhedrosis in the vicinity. These observations show the possibility of utilizing artificial baits for wasps and other predators in the spread of virus diseases.

The foregoing observations are worthy of report since to our knowledge no records have ever been made of predatory insects transmitting virus diseases to other insects.

Acknowledgment

The author wishes to express his thanks to Dr. F. T. Bird of the Insect Pathology Laboratory, Sault Ste. Marie, Ont., for reviewing this paper.

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A New Genus and Three New Species of Aphididae (Homoptera)[1]

By W. R. Richards[2]
Insect Systematics and Biological Control Unit
Entomology Division, Ottawa, Canada

In recent years there has been a renewed interest in aphids, primarily as to their role in the dissemination of plant viruses. As a result many new species are being discovered, even on some of the more common plants. The notes and descriptions that follow arise from collections made in British Columbia.

Fimbriaphis, new genus

Type species: *Fimbriaphis fimbriata* Richards, new species.

Apterous Viviparous Female.—Frontal tubercles well developed, scabrous, parallel to slightly converging; median tubercle prominent. Disc of head smooth. Antenna shorter than body; primary sensoria with strongly ciliated margins, secondary sensoria absent. Rostrum reaching just beyond second coxa; six to 11 setae in addition to usual three apical pairs. First segment of each tarsus with three setae. Dorsum of abdomen without pigmented sclerotic areas. Cornicle not swollen on apical half, slightly curved; orifice oblique. Cauda elongate, sides almost parallel, slightly constricted before middle, with two setae on each side and one or two dorsal preapical ones. Short, blunt setae on dorsum of head and body and on antenna and legs except apices of tibiae; pointed setae elsewhere.

Alate Viviparous Female.—Dorsum of head smooth. Secondary sensoria restricted to third antennal segment, arranged in a single irregular row on posterior surface, each sensorium with fine, cilia-like, marginal fimbriations. Media of forewing two-branched. Dorsum of abdomen with a large, irregularly shaped, pigmented sclerotic patch; tergum VIII with or without median tubercles. Lateral abdominal sclerotic patches well developed. Cornicle weakly reticulate proximad of flange. Otherwise esesntially as in apterous viviparous female.

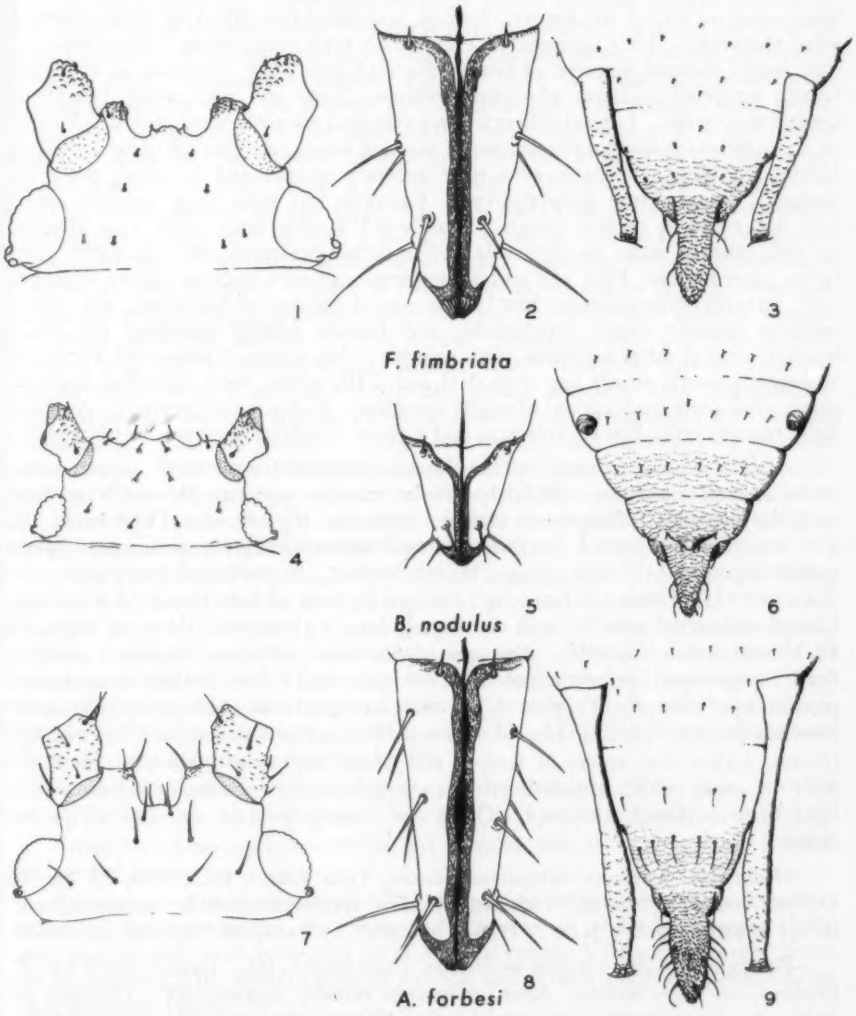
First-instar Nymph.—Frontal tubercles well developed, scabrous. Antennae four-segmented. Hind tibia without spicules. First segment of each tarsus with two setae.

Comments.—The chief distinguishing feature of this genus is the presence of the fine, cilialike fimbriations of the margins of the secondary sensoria. It is very closely related to *Rhodobium* H. R. L., from which it can be distinguished by the absence of secondary sensoria in the apterae and also their absence on the fourth and fifth antennal segments in the alatae. The genus is associated with *Vaccinium* sp. and *Fragaria* sp.

[1]Contribution No. 3870, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.
[2]Associate Entomologist.

In North America the only other species that is referable to this genus is *Myzus scammelli* Mason (1942), which occurs on *Vaccinium* sp. in eastern North America. This species can be distinguished from the type species by means of the following key:

1. Alate viviparae with a large, irregularly shaped, pigmented sclerotic patch on dorsum of abdomen; unguis in apterous viviparae 0.4 mm. or longer; western species on strawberries ..... *fimbriata*, Richards, new species
Alate viviparae without a sclerotic patch as described above; unguis in apterae up to .33 mm. long; eastern species on *Vaccinium* sp. ..... *scammelli* (Mason)



Figs. 1, 4, 7. Dorsa of heads of apterous viviparous females. Figs. 2, 5, 8. Apical rostral segments of apterous viviparous females. Figs. 3, 6, 9. Dorsal views of apices of abdomens of apterous viviparous females.

***Fimbriaphis fimbriata*, new species**

Apterous Viviparous Female (*Holotype*).—Dorsum of head with eight short, blunt setae; slightly spiculose near bases of antennae and on frontal tubercles. Frontal tubercles well developed, scabrous, slightly converging, each with three short, blunt setae. Antenna slightly longer than body; without secondary sensoria, primary sensoria with strongly fimbriate margins. Antennal setae short, blunt, less than half basal diameter of segment III. Lengths of antennal segments; III, 0.4 mm.; IV, 0.23 mm.; V, 0.25 mm.; VI, 0.12 mm. - 0.47 mm. Rostrum reaching slightly beyond middle coxa; apical segment 0.1 mm. long, with eight setae in addition to usual three apical pairs. Dorsum of thorax with short, blunt, inconspicuous setae; without pigmented sclerotic areas. Short, blunt setae on coxae, trochanters, femora, and basal four-fifths of tibiae; pointed setae elsewhere. First segment of each tarsus with three setae. Hind tibia 0.1 mm. long. Second segment of hind tarsus 0.12 mm. long. Dorsum of abdomen faintly wrinkled, without pigmented sclerotic areas and with short, blunt, inconspicuous setae. Lateral tubercles and marginal sclerotic areas absent. Venter of abdomen with short, inconspicuous, pointed setae. Subgenital plate wrinkled, lacking spicules, with two setae near anterior margin and 11 along posterior margin. Three setose gonapophyses. Cornicle 0.45 mm. long, curved; apical half not swollen; orifice oblique. Cauda 0.275 mm. long, with two slender, curved, pointed setae on each side and a dorsal preapical one. Spiracles reniform. Integument: First and second antennal segments scabrous, other segments with smooth imbrications; first three rostral segments spiculose, the apical segment smooth; coxae, trochanters, and femora faintly spiculose, the tibiae smooth; second tarsal segments with smooth imbrications; dorsum and venter of abdomen smooth except for terga VII and VIII, which have spiculose imbrications; anal plate and cauda strongly spiculose. Colour (macerated): Antenna light brown; tarsi, tips of rostrum, and base of antennal segment VI darker.

Alate Viviparous Female.—Third antennal segment with 10 to 16 secondary sensoria, each sensorium with finely ciliated margins; segments IV and V without secondary sensoria. Lengths of antennal segments: III, 0.65 mm.; IV, 0.5 mm.; V, 0.45 mm.; VI, 0.15 mm. - 0.6 mm. Frontal tubercles slightly scabrous. Apical rostral segment 0.125 mm. long. Wings hyaline, the media of forewings two-branched. Hind tibia 1.5 mm. long. Second segment of hind tarsus 0.1 mm. long. Lateral abdominal sclerites well developed, deeply pigmented, those on segments III-V with small tubercles. Dorsum of abdomen with an irregularly shaped, deeply pigmented, sclerotic patch. Cornicle with a few distinct reticulations proximad of flange. Tergum VIII without tubercles. Colour (macerated): Antenna brown, lighter at base of segment III; head and thorax dark brown; legs brown, darker near apices of femora and tibiae; abdomen colourless except for sclerotic areas, which are dark brown; cornicle brown, darker near base; cauda light brown. Length 0.2 mm. Otherwise essentially as in apterous viviparous female.

Holotype.—Apterous viviparous female, Lulu Island, B.C., June 23 (A. R. Forbes), on strawberries, produced by alate viviparous female (paratype) collected in same locality June 2, 1958. No. 6717 in Canadian National Collection.

Paratypes.—Alate viviparous female, Lulu Island, B.C. June 2, 1958 (A. R. Forbes), on strawberries. Alate viviparous female, Agassiz, B.C., October 11, 1956 (R. Stace-Smith), on strawberries. Three apterous viviparous females, Lulu Island, B.C., June 13, 1958 (A. R. Forbes), on strawberries; part of progeny of alate viviparous female collected at same locality, June 2, 1958. Ten apterous

viviparous females, Lulu Island, B.C., July 17, 1957 (A. R. Forbes), on strawberries. No. 6717 in Canadian National Collection.

***Brachycolus nodulus*, new species**

Apterous Viviparous Female (*Holotype*).—Dorsum of head with eight weakly capitate setae; without spicules. Frontal tubercles evident, not exceeding median tubercle, each with two weakly capitate setae. Antenna shorter than body; without secondary sensoria; primary sensoria with strong, marginal, cilia-like fimbriations. Antennal setae short, equal to half basal diameter of segment III. Lengths of antennal segments as follows: III, 0.225 mm.; IV, 0.125 mm.; V, 0.125 mm.; VI, 0.125 - 0.15 mm. Rostrum barely attaining second coxae; 0.06 mm. long; apical segment with two basal setae in addition to usual three apical pairs. Dorsum of thorax with short, slightly capitate setae; without pigmented sclerotic areas. Pointed and slightly capitate setae on coxae and trochanters; distinctly capitate setae on femora and on most of tibiae except near apices, where they are pointed. Three setae on first tarsal segments of fore and middle legs, two setae on first segment of each hind tarsus. Hind tibia 0.6 mm. long. Second segment of hind tarsus 0.15 mm. long. Abdomen without pigmented sclerotic areas, smooth except terga VI, VII, and VIII, which have spiculose imbrications. Tergum VIII with a triangular tubercle that has a weakly capitate seta on each side. Dorsal abdominal setae weakly capitate; ventral ones pointed, arranged in two irregular, transverse rows. Spiracles oval or slightly reniform. Subgenital plate strongly spiculose, with two pointed setae near anterior margin, ten along posterior margin. Three setose gonapophyses. Cornicle minute, about as long as first segment of hind tarsus. Cauda triangular with two curved, pointed setae on each side and a capitate, dorsal preapical one. Integument: First and second antennal segments slightly scabrous, other segments with smooth imbrications. Rostrum smooth. Coxae, trochanters, and femora with spiculose imbrications. Dorsum of abdomen smooth except terga VII and VIII, which have spiculose imbrications; venter of abdomen faintly spiculose. Genital plate, anal plate, and cauda strongly spiculose. Colour (macerated): Brown, cornicle, cauda, legs, and apical three antennal segments darker. Length two mm.

Alate Viviparous Female.—Third antennal segment with five or six secondary sensoria, fourth with one or two. Lengths of antennal segments: III, 0.175 mm.; IV, 0.125 mm.; V, 0.125 mm.; VI, 0.1 mm. - 0.16 mm. Frontal tubercles slightly scabrous. Apical rostral segment 0.065 mm. long. Wings hyaline; media of forewing two-branched. Hind tibia 0.6 mm. long. Second segment of hind tarsus 0.15 mm. Lateral abdominal sclerites present, small; tubercles absent. Tergum VIII with a triangular median tubercle. Length 1.5 mm. Otherwise essentially as in apterous viviparous female.

Holotype.—Apterous viviparous female, Summerland, B.C., Sept. 6, 1955 (D. P. Pielou), on orchard grass. No. 6718 in Canadian National Collection.

Paratypes.—Four apterous viviparous females, ten alate viviparous females. Data as for holotype.

Comments.—This species is readily distinguished from other North American species of *Brachycolus* by the triangular tubercle on abdominal tergite VIII. Other species that have a tubercle on abdominal tergite VIII are *B. noxius* Mord. and *B. mühlei* C. B., which occur in Europe and Africa (Börner, 1950; Eastop, 1955; Uvarov, 1922).

***Amphorophora forbesi*, new species**

Apterous Viviparous Female (*Holotype*).—Dorsum of head smooth, with eight sharply pointed setae, each of which is slightly longer than basal diameter

of antennal segment III. Frontal tubercles well developed, slightly diverging, each with a few spicules; median tubercle evident, but poorly developed. Antenna slightly shorter than body, without secondary sensoria. Setae on first two antennal segments sharply pointed and longer than basal diameter of segment III; setae on other segments blunt, shorter than half basal diameter of segment III. Lengths of antennal segments: III, 0.85 mm.; IV, 0.675 mm.; V, 0.575 mm.; VI, 0.175 mm.-1.25 mm. Rostrum reaching slightly beyond middle coxa; apical segment 0.175 mm. long, with 13 setae in addition to usual three apical pairs. Dorsum of thorax with very short, blunt, inconspicuous setae. Short, blunt, appressed setae on dorsa of femora. First segment of each tarsus with three setae. Hind tibia 2.8 mm. long. Second segment of hind tarsus 0.15 mm. long. Dorsum of abdomen without pigmented sclerotic areas; with blunt, inconspicuous setae except on terga VII and VIII, where they are long and sharply pointed. Lateral abdominal tubercles and sclerites absent. Spiracles weakly reniform. Venter of abdomen with long, sharply pointed setae. Subgenital plate with two setae on anterior margin, eight on central area, and eleven on posterior margin. Three setose gonapophyses. Subgenital plate, anal plate, and cauda strongly spiculose. Cauda with six to eight setae on each side and three or four dorsal ones. Integument: First and second antennal segments scabrous, other segments with smooth imbrications. Dorsum of head smooth except for a few spicules on frontal tubercles; venter strongly and evenly spiculose. Abdomen smooth except terga VII and VIII, which have spiculose imbrications. Cornicle with a few weakly spiculose imbrications on swollen part. Colour (macerated): Very light brown; tarsi and apices of tibiae and of cornicles darker. Length 3.8 mm.

Alate Viviparous Female.—Antennal segment III with 13 to 20 secondary sensoria, arranged in a straight line on posterior surface; segments without sensoria. Lengths of antennal segments: III, 0.9 mm.; IV, 0.7 mm.; V, 0.55 mm.; VI, 0.175 mm.-1.2 mm. Frontal tubercles smooth, slightly diverging. Apical rostral segments 0.15 mm. long. Wings hyaline except for a narrow fuscous border along each vein; media of fore-wing two-branched. Hind tibia 3.7 mm. long. Second segment of hind tarsus 0.125 mm. long. Lateral abdominal tubercles and sclerites absent. Dorsum of abdomen without pigmented sclerotic areas. Length 3.1 mm. Otherwise essentially as in apterous viviparous female.

Holotype.—Apterous viviparous female, Lulu Island, B.C., June 2, 1958, on *Rubus spectabilis* Pursh. (A. R. Forbes). No. 6719 in Canadian National Collection.

Paratypes.—42 apterous viviparous females and five alate viviparous females. Data as for holotype.

Comments.—This species is readily distinguished from other members of the genus by the absence of secondary sensoria on antennal segment III. In this respect *A. forbesi* resembles various species now placed in *Wahlgreniella* H. R. L., but species placed in this genus have only five caudal setae. The species is named in honour of its collector.

Acknowledgments

Special thanks are gratefully extended to: A. R. Forbes, Entomology Section, Canada Department of Agriculture Research Laboratory, Vancouver, B.C., for collecting and rearing some of the material used in this study; to Hille Ris Lambers, Bennekom, Netherlands, for his opinions on the species of *Brachycolus*, and *Fimbriaphis*.

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Note on Two Species of Leafhoppers (Homoptera: Cicadellidae) New to Canada[1]

By J. A. GEORGE
Entomology Laboratory, Vineland Station, Ontario

Three specimens of a species of leafhopper new to the Niagara Peninsula were collected during 1956 along the wooded bank of Niagara River below Queenston, Ontario; they were identified by Mrs. C. J. Williams, Entomology Division, Ottawa, as *Orientus ishidae* (Mat.) and are in the Canadian National Collection. According to Oman (1949), this is an introduced Japanese species which lives on willow and is widely distributed. Presumably Oman's statement is based on collections made in the United States as Mrs. Williams stated (in litt.) that this was the first record from Canada.

During August and September, 1957, about 200 specimens of *Japananus hyalinus* (Osb.) were collected by sweeping Norway maple trees along the Niagara River below Queenston, Ontario, and identified by Mrs. Williams, who stated (in litt.) that they were the first specimens of this species recorded from Canada, Specimens are in the Canadian National Collection. During September 1-15, 1958, it was collected on sticky boards hung in the foliage of sour cherry trees in an orchard at St. Catharines, Ontario. According to DeLong (1948), this species was introduced from the Orient and occurs commonly upon maples in Illinois and the eastern United States.

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[1]Contribution No. 3909, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

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Potential Usefulness of Vinyl Latices as Stickers[1]

By T. A. Angus
Insect Pathology Laboratory, Sault Ste. Marie, Ont.

In 1954, the use of Methocel (methyl cellulose) as a sticker in laboratory studies of bacterial pathogens was described (1). Although satisfactory for laboratory use, Methocel is not practical for field use because of its solubility in water. In a field experiment 1½ inches of rain in two hours reduced by 80 per cent the residual count of bacteria applied as a suspension in Methocel. In a search for a more satisfactory sticker for field use, colloidal dispersions of vinyl chloride polymers and copolymers in water have been tested. These trials have been sufficiently encouraging to justify a preliminary report of the results.

Ideally, a suitable sticker for field applications should be stable, be water-dispersible but not water-soluble, be non-toxic to plants and animals, form a slightly flexible adherent bond at outdoor summer temperatures, and not inhibit the biological activity of the pathogen being applied to the foliage. Most of these requirements are met by the Geon Latices manufactured by the B. F. Goodrich Chemical Co. of Kitchener, Ont., who kindly supplied samples of their Geon latex 652 for use in the following tests:

(1) As an index of the persistence of the latex film on foliage, a quantity of the dye Sudan IV was ground in a mortar with diatomaceous earth to reduce particle size and suspended in a 10 per cent (v/v) latex-water dispersion. The dye-sticker suspension was applied by a hand sprayer to the foliage of small spruce, oak, cedar, and mulberry trees. Samples of foliage were taken twice weekly and tested for the presence of dye by covering the foliage with sheets of bibulous paper wetted with a few drops of xylol. After six weeks of outdoor exposure in September and October the dye was still detectable on all types of foliage. On examination the foliage appeared normal.

(2) Stainless-steel planchets were coated with equal aliquots of a suspension of amorphous C^{14} in 10 per cent latex. The coated planchets were air-dried and then immersed in moving water at 20°C. Planchets were removed at various times and residual activity determined. After three hours' immersion there was no significant reduction of activity, indicating that the latex film was still intact.

(3) Small mulberry leaves were coated with full strength Geon latex 652 (0.05 ml.), air dried and fed to silkworm larvae. The insects fed readily, and after 24 hours appeared normal, indicating that the latex, at the level used, was palatable and innocuous.

(4) A few drops of a heavy suspension of *Bacillus thuringiensis* var. *thuringiensis* (2) were added to 100 ml. of 10 per cent latex dispersion. A similar quantity of cells was suspended in 100 ml. of water. The mixtures were incubated and samples taken to determine numbers of surviving cells. After three hours exposure to the latex there was no appreciable reduction in numbers of viable cells in the latex suspension.

(5) A number of small potted mulberry plants were sprayed with a suspension of *B. thuringiensis* var. *thuringiensis* in a 10 per cent latex dispersion. After the coating was dry (about 30 minutes) plants were treated in various ways, and samples of the foliage tested for pathogenicity against silkworm larvae.

(a) One plant was sprinkled daily for three minutes with water from a domestic garden hose. Foliage samples were taken and tested for toxicity after each sprinkling. After two weeks the foliage was still toxic.

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(b) The stems and leaves of another coated plant were immersed in a tank of water at 20°C. The water was kept in rapid motion by a power stirrer and fresh water was added constantly at a rate equivalent to four complete changes an hour. Samples of foliage were taken at two-hour intervals and tested for toxicity. After 12 hours continuous immersion the foliage was still toxic.

(c) A third coated plant, with the pot and lower stem wrapped in metal foil, was placed in a shower cabinet and exposed to a heavy spray of cold water. The shower head was about six feet above the foliage, and the streams of water struck the leaves with considerable force. Samples were taken at two-hour intervals and tested for toxicity. After 12 hours continuous washing the foliage was still toxic.

(6) In limited tests, polyhedra of the virus disease of the spruce sawfly were suspended in 10 per cent latex and sprayed on spruce foliage. The latex did not appear to inhibit the infectivity of the pathogen.

These results indicate that the latex, as used, was a satisfactory sticker for microorganisms. Methods of applying the material and evaluating results have been developed empirically and therefore may not be optimal. The manufacturers indicate that different formulations of latices might be even more satisfactory. Tests of some of these are now in hand.

The Geon latices are compatible with a wide variety of compounds, suggesting that it might be possible to incorporate insecticides in a weather-resistant film. A quantity (5 gram) of commercial 50 per cent wettable DDT powder was suspended in 10 per cent latex and sprayed on spruce foliage. The Geon 652 did not appear to inhibit the insecticide as a stomach poison for the spruce sawfly but there may be some reduction of its effect as a contact poison. These tests, very limited in extent, suggest that the Geon latices may be useful in solving some insecticide problems.

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Note on *Epigonatopus plesius* (Fenton) (Hymenoptera: Dryinidae), a Parasite of the Six-Spotted Leafhopper, *Macrosteles fascifrons* (Stal), in Ontario[1]

By J. A. GEORGE
Entomology Laboratory, Vineland Station, Ontario

During studies on the aster yellows virus in the Niagara Peninsula of Ontario, the dryinid parasite *Epigonatopus plesius* (Fenton), has been observed since 1956 on the nymphs and adults of the six-spotted leafhopper, *Macrosteles fascifrons* (Stål). During 1956 adult females of *E. plesius* reared from this host were identified by Mr. K. V. Krombein of the U.S. National Museum, Washington, D.C. Dr. W. R. M. Mason (1957) Entomology Division, Ottawa, wrote, "This is a very rare species. There are only two collections in Washington and only yours in the Canadian National Collection".

The female was described by Fenton (1927) "from three specimens reared from jassids, in 1914 by C. N. Ainslie." During 1957 the hitherto unknown males were reared from identified females and were observed mating with other identified ones. Sexual dimorphism is so great that the sexes could not be associated by a museum taxonomist, the females being wingless and the males winged. Specimens of both sexes have been deposited in the Canadian National Collection.

E. plesius was reared through its life cycle on *M. fascifrons;* other hosts, if any, are not known. Females prey upon as well as parasitize this leafhopper. As the incidence of parasitism appeared to be very low, the economic importance of the parasite may not be great.

Reference

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